Phonological acquisition and development in Arabic-English bilingual children

Phonological Acquisition and development in Arabic- English Bilingual Children

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Declaration

I declare that the thesis submitted is my own work and that appropriate credit has been given where reference has been made to the work of others.

Asma Alamer
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This thesis would not have been possible without the contribution of my three special participants. I would like to express my gratitude and endless appreciation to their mothers who dedicated their time in eliciting and recording their children speech for one year.

At one point or another, I almost lost hope of completing this thesis. Giving birth to two children while immersing myself in the process of analyzing and writing was almost an impossible mission. Thus, towards the end it felt that I have finally giving birth to my third child. I was very fortunate to have a supervisor like Prof. Zhu whose support and encouragements were valuable. The support that I received from my supervisor was not merely academic; at times of despair and self-doubt she would restore my self-confidence with her kind words and encouragements.

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Abstract

The main aim of this thesis is to explore the effect of cross-linguistic interaction on the phonological acquisition and development of simultaneous pre-school bilingual children. Data sample comprise of elicited single words and spontaneous speech obtained for three children acquiring English and Arabic languages and recorded by their mothers at home on a monthly basis for a period of one year. The extent of cross-linguistic interaction between the bilingual children's two language was examined through three manifestations: (a) transfer; (b) delay; and (c) acceleration (Paradis & Genesee, 1996) against consonant accuracy PCC, phonemic repertoire, and error patterns.

Findings revealed evidence of cross-linguistic interaction through transfer and acceleration at variable degrees across the participants. For transfer, bi-directional transfer was observed in the production of the phoneme /r/ by two of the participants, while unidirectional transfer was more frequent and influenced the production of the following phonemes; /r/, /l/, /ɬ/ and /ŋ/. The directionality of transfer and its frequency corresponded to language exposure patterns the children were exposed to. Acceleration was observed in segmental inventories of shared and unshared sounds. One of the participants had an accelerated inventory of shared sound cross-linguistically when she was less than three years. Conversely, the other participants reported an accelerated segmental inventory in Arabic of unshared sounds over the age of three. In addition, acceleration of the PCC scores in both languages was evident in the results of one of the participants who received amble language exposure in both languages. Delay on the other hand was not found to be a manifestation of interaction and was the result of insufficient language exposure received in the participants' concerned languages. This was also the case of error pattern in which its frequency is contingent on the amount of language exposure received. Longitudinally, interaction either decreased or resolved demonstrating the boosting mechanism of interaction that could manifest at varying degrees during acquisition.

The main contribution of this thesis, apart from its being the first longitudinal exploration of English/Arabic simultaneous preschool bilingual children in the UK, is the positive effect of a certain threshold of language exposure across the bilinguals' languages in promoting higher accuracy and larger segmental inventory in comparison to their age matched monolinguals.

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1 Introduction

The year of 2005 marked the inception of the King Abdullah scholarship program. Thousands of Saudis applied and were given scholarships to study aboard in the United States, Canada, and the United Kingdom, among other countries. The goal of this program was not only to provide the country with a highly-skilled workforce to meet different needs in the public and private sectors but also to provide opportunities for its citizens to experience different cultures, ideas and ways of thinking. This anticipated change of mind-sets was expected to have great social and cultural impact. Scholarships were offered in abundance and impacted most households in Saudi Arabia. Tens of thousands of Saudis travelled with their families abroad, which led to a dramatic increase in bilingualism among Saudi children who acquired English and Arabic simultaneously. Additionally, mass waves of immigration took place after the Arab spring, displacing more than 16 million refugees worldwide from Arabic countries such as Iraq, Libya, and Syria (Kingsley, 2015). This movement contributed to an increase in bilingual Arabic children learning the language of their host countries. With these changes, an immense need to fill the research gap for these populations' phonological acquisition and development has emerged. This exploration set out to bridge the gap in the literature of bilingual children of Arabic-speaking background.

The findings of this study will be useful for language therapists, educationists and parents as the journeys of three English/Arabic simultaneous bilingual children with different language exposure patterns unfold. This investigation seeks to explore the role of environmental and linguistic factors on the bilingual phonological acquisition in general and on the phenomena of interaction in particular.

1.1 Concepts and Definitions

In this section, I will provide general definitions of several important concepts and terminology that will be used throughout this thesis. I will commence by answering the question of what it means to be bilingual. Typology of bilingual children is also relevant to this investigation, given the heterogeneity of the bilingual population that could be categorized in different subcategories in accordance to the age of language exposure, or what is sometimes been referred to as *age of arrival* (AOA) or language dominance.

1.1.1 Bilingualism

Commonly, the term bilingualism refers to an individual's ability to communicate in two languages. This generic definition could be problematic, as bilinguals do not represent a homogenous population. Beardsmore (1986) stated that 'bilingualism as a concept has open-ended semantic' (p. 1). Indeed, an abundance of definitions circulated in literature does not specify the level of language proficiency required nor provide any information concerning the age of exposure to the second language. This ambiguity could lead to misleading conclusions and false generalization. To overcome this shortcoming, a typology of bilinguals was proposed by scholars considering different criteria. The discussion will be limited to two sets of classifications based on language proficiency and age of language exposure.

1.1.1.1 Simultaneous vs. Sequential Bilingual

A simultaneous and sequential bilingual distinction is based on the age of language exposure. This mainly concerns the age at which the child was exposed to the second language. Children who were exposed to both languages from birth or up to the age of three are categorized as simultaneous bilinguals. Investigation in this area is often referred to as bilingual first language acquisition (BFLA). On the other hand, children who were exposed to another language after they turned three are viewed as sequential or successive bilinguals. This distinction is not meant to be absolute but is widely accepted among researchers in the field (Genesee *et al.*, 2011). These concepts have been proposed to distinguish bilingual first language acquisition (BFLA) from bilingual second language acquisition (BSLA), which tend to employ different processes in language acquisition and learning.

In addition, this distinction does not postulate that either type will or will not acquire a native-like competence. Regular exposure and opportunity are important conditions in acquiring a language. This contrast will lead us to the second categorization of bilinguals, which concerns language exposure as defined below.

1.1.1.2 Balanced vs. Unbalanced Bilinguals

Another important distinction of the bilingual population is based on degrees of language attainment or proficiency. This widely recognized concept sets apart two types of bilinguals: balanced and unbalanced. Balanced bilinguals are presumably those bilinguals who are provided with sufficient language exposure in both languages. Sufficiency of language exposure does not necessitate equality in quantity

but rather in quality (Genesee *et al.*, 2011). Unbalanced, or what is referred to be dominant bilinguals, are those who acquired relatively higher proficiency of one language over the other. It is crucial to point out that this distinction is not fixed, and balanced bilingual children could become unbalanced during their acquisition depending on the communicative needs and challenges they face.

1.2 Bilingual first language acquisition research: Theoretical background

1.2.1 One vs. two phonological systems

Two historical landmarks can be identified in the literature of BFLA: unitary language model (ULM) and dual language system hypothesis (DLS). The overriding assumption of the early period was that linguistic differentiation is preceded by an undifferentiated single system at the onset of acquisition (Vogel, 1975; Schnitzer & Krasinski, 1994 among other scholars). Empirical basis and evidence that were often cited by ULM proponents have been refuted based on conceptual and methodological limitations. As a result, alternative models of language acquisition have been proposed and developed. The current assumption about bilingual acquisition in the literature supports the notion of non-autonomous differentiated mental representation from the beginning or what is referred to as interactional dual system model.

1.2.1.1 Unitary Language Model (ULM)

The unitary language model hypothesis received substantial support from scholars in the field of first bilingual acquisition since the early nineties an up to the

beginning of the twentieth century. Its central premise is that bilingual children who acquire more than one language simultaneously during infancy start with a single neurocognitive system at the initial stages of their language development followed by linguistic differentiation at age three (Genesee, 1989; Paradis *et al.*, 2011). Evidence used to support this model in different linguistic domains such as lexical, syntactic and phonological will be reviewed and examined in the following paragraphs.

Concerning phonology, various researchers such as Vogel (1975) and Celce-Murcia (1978, cited in Paradis *et al.*, 2011) concluded that their bilingual subjects had a single undifferentiated system for both of their languages. This observation was based on the application of the same substitution patterns across their languages irrespective of language-specific principles.

In addition, Schnitzer and Krasinski's (1994) longitudinal study of a simultaneous Spanish-English bilingual child from 1;1 through 3;9 revealed that consonantal acquisition passed through four stages while vocalic acquisition seemed to be differentiated from the beginning. The four stages of consonantal acquisition started with: a) the establishment of the unitary system from 1; 11 - 2; 2; b) the establishment of separate system during 2;3 - 2;7; c) the achievement of target value of the adult system, which stabilized at 3;2 years; and d) later interference. The authors set language separation as a fundamental pre-requisite for interference to take place. Therefore, early instances of interference-resembled structures may have been due to an undistinguished unitary system in their view.

Claims of a unitary system have been based on several isolated occurrences of mixed elements at the early stages of linguistic representations prior to the emergence of functional linguistic categories. These mixed elements were observed in different linguistic domains (e.g. phonological, syntactic) at different timeframes. For example,

Schnitzer and Krasinski (1994) noted that vowels were differentiated from the beginning while consonant acquisition went through various stages, and Volterra and Taeschner (1978) revealed that syntactic differentiation is preceded by lexicon differentiation. Regardless of these variations, all studies agree that complete linguistic differentiation takes place after the age of three.

In terms of an undifferentiated lexicon and syntax, Volterra and Taeschner (1978) claimed that lexical and syntactic development go through different stages, starting with a unitary lexicon followed by differentiated lexical systems with single syntactic rules. After this stage, distinguished linguistic codes with differentiated lexicon and syntax will emerge, and at this point the child could be viewed as truly bilingual. Evidence of a unitary lexicon was taken from an absence of translation equivalents in their subjects' productive vocabularies. On the other hand, one source of evidence of a unified syntactic rule system was the application of the same syntactic rules across languages even if they do not correspond to the target language's syntactic rules.

Regarding phonological acquisition, researchers have interpreted the presence of common substitution patterns across bilingual children's languages as a sign of a unitary phonological system (Vogel, 1975; Celce-Murcia, 1978; Schnitzer & Krasinski, 1994). However, the nature of cross-linguistic commonalities across languages in the composition of early segmental and substitution patterns challenges the validity of this argument. Paradis (2001) argued whether these similarities were the result of an undifferentiated system or due to the absence of language-specific properties at the point of development, which is also observed in monolingual acquisition. She voiced two concerns: First, conclusions of previous studies were based on the findings from single case studies that restrained generalizability and

instead highlighted individual variations; second, these studies did not consider commonalities of phonological acquisition cross-linguistically through addressing monolingual acquisition norms in each language. It is crucial to account for the language-specific phonological properties; otherwise, cross-linguistic similarity among children could be viewed as a sign of a single system.

1.2.1.2 Dual Language System Hypothesis (DLS)

Since early studies used to support the ULM have been challenged at methodological and empirical grounds, abundance of systematic research emerged to re-examine the question of whether bilingual children start with a unitary linguistic system. In Genesee's (1989) systematic review, he indicated that evidence used for supporting ULM was based on isolated and infrequent occurrences of mixed linguistic elements without any account for the contexts of these productions and argued that these elements are not an indication of a unitary linguistic system. He then proposed an alternative model, which was later termed as the dual language system hypothesis. The dual language system hypothesis assumes that simultaneous bilingual children acquire two separate linguistic systems from the onset of acquisition.

Extensive support for DLS has been established by subsequent empirical investigations relating to different linguistic domains. Evidence for pragmatic separation was attested for in a study by Genesee *et al.* (1995). The authors examined the frequency of cross-linguistic mixing in the speech production of five French-English bilingual children aged between 1; 10 - 2; 2. The data analysis indicated that, at age two, bilingual children have two differentiated linguistic systems. Moreover, at that early age, it was evident that children could make appropriate linguistic choices

in contextually sensitive ways. The authors examined the role of other factors, such as mixing in parental input and language dominance on the rate of code mixing. They concluded that parental input had no significant connection with the frequency of children's mixing while language dominance was assumed to play an important role. Two of the children were further examined to evaluate their code mixing in a novel linguistic context by observing their interaction with English monolingual speakers. Children were found to be able to discriminate between both of their languages by using their languages in a context-sensitive manner.

A follow-up study was conducted by Genesee *et al.* (1996) to examine the bilingual children's speech behaviour with unfamiliar conversational partners, since the children may have had time to associate each language with different parents in the previous study. Three of the four bilingual children were observed to accommodate to the stranger's language by minimizing their use of the other language. This accommodation was clear evidence of differentiation between the two languages in which their linguistic choices were context-sensitive. The finding, therefore, demonstrated that code-mixing was not a sign of confusion or lack of differentiation but an active mechanism of filling the gaps and overcoming difficulties or lack of proficiency.

With regards to phonological differentiation, research supported early differentiation. A longitudinal investigation conducted by Deuchar and Clark (1996) on their daughter revealed that her phonological development proceeded with no initial system followed by differentiated two phonological systems as contradictory to what ULM promotes. Similarly, Schnitzer and Krasinski's (1996) longitudinal study demonstrated that their son developed two separated phonological systems from the outset of acquisition with minimal interaction. This revelation is significant since their

previous study (Schnitzer & Krasinski, 1994) of an older sibling revealed contradictory findings supporting the ULM. These two studies were conducted on children acquiring Spanish and English language simultaneously.

Correspondingly, findings of different language combinations on phonological acquisition supported DLS as well. Johnson and Lancaster (1998) and Keshavarz and Ingram (2002) examined the early phonological attainment of bilingual children before the age of two, acquiring Norwegian-English and Farsi-English language combinations, respectively. Both used a single case study design, and their findings supported DLS. Nonetheless, Johnson and Lancaster's (1998) study indicated a level of mutual systematic cross-linguistic interaction, while Keshavarz and Ingram (2002) provided evidence of a minimal level of influence in specific contexts where one language predominates the other.

Paradis (2001) adopted a different methodology using an experimental paradigm and included a larger sample size than in previously reported studies. The sample included seventeen French-English bilingual children as well as eighteen monolingual children in each language as comparison groups. The findings of the study indicated that French-English two-year-old bilingual children have separated but non-autonomous phonological systems. This separation is not sealed and cross-linguistic interaction could manifest at different points during acquisition. The hypothesis proposed by Paradis (2001), termed as interactional dual system model and viewed interaction as an inevitable stage in bilingual phonological acquisition.

While the current view in the literature supports the interactional dual system language model in accounting for bilingual language acquisition, some findings were subject to different interpretations in regards to the rate and frequency of cross-linguistic interaction phenomenon. The aim of the following literature review is to

summarise findings on cross-linguistic interaction in phonological acquisition studies reported in recent investigations of pre-school bilingual children.

1.2.2 Cross-linguistic Interaction

Findings in the field of bilingual first language acquisition indicate a level of mutual influence of the two linguistic systems over each other in the interim of language acquisition (Genesee *et al.*, 1996; Paradis, 2001; Keshavarz & Ingram, 2002). This influence is perceived as cross-linguistic interaction and defined by Paradis and Genesee (1996) as 'the systemic influence of the grammar of one language on the grammar of the other language during acquisition, causing differences in a bilingual's patterns and rates of development in comparison with a monolingual's' (p. 3). Though in their investigation the authors were referring to syntactic acquisition and they used the term 'interdependence,' their hypothesis was the theoretical basis of successive research in many subfields of bilingual acquisition.

1.2.2.1 Manifestations of Cross-linguistic Interaction

According to Paradis and Genesee's (1996) model, there are quantitative and qualitative differences between monolingual and bilingual acquisition caused by a cross-linguistic interaction of the bilingual's two languages. This interaction has three manifestations: transfer, acceleration and delay. The aim of this section is to review empirical evidence of these signs reported in the literature.

Transfer

Instances of transfer were observed extensively in bilingual acquisition studies at different rates and frequencies. Paradis and Genesee (1996) proposed that transfer 'consists of the incorporation of a grammatical property into one language from the other' (p. 3). Though their focus was on syntactic acquisition, researchers have applied this concept to different linguistic domains using a similar conceptual framework. Fabiano-Smith and Goldstein (2010) identified segmental transfer as the transfer of consonants and vowels that are specific to one language to the production of the other language (p. 161). Most reported accounts of transfer occurred at low frequency (Fantini, 1985; Schnitzer & Krasinski, 1996; Fabiano-Smith & Goldstein, 2010; Goldstein & Bunta, 2012) and affected different phonological subcomponents at different time frames. Several scholars identified language asymmetry as an important factor in predicting which structures are more susceptible to cross-linguistic transfer (Döpke, 2000; Paradis, 2001). The directionality of transfer, in which two types emerge: bi-directional transfer and uni-directional, has also received considerable attention. Bi-directional transfer affects both languages and could be also determined by points of structural ambiguity, while uni-directional transfer usually is directed by language dominance and only affects the less proficient language.

The occurrence of uni-directional transfer is usually attributed to language dominance and its influence on the acquisition of the least proficient language. For example, Paradis (2001) examined the truncation patterns of seventeen French-English bilingual children and their monolingual peers. Her findings indicated that structurally ambiguous forms, specifically the truncation patterns of WS'WS words in English, were influenced by transfer. The bilingual group, specifically the French

dominant bilingual children, tended to exhibit an iambic bias (WS) while English monolingual children displayed a trochaic rhythm (SW) in their truncation patterns of weak syllables, which indicates that language dominance plays a critical role in determining the directionality of transfer. Another study of a longitudinal nature by Keshavarz and Ingram (2002) examined the phonological acquisition of a Farsi-English bilingual child; they reported few cases of transfer. At the early stages of lexical acquisition, they observed some influence of Farsi's stress over English production of first words. However, transfer was later evident from English to Farsi when English became the child's dominant language.

In bi-directional transfer, both languages influence each another in a systematic way. This type of transfer is usually reported at a minimum level and resolved over the period of acquisition. Fabiano-Smith and Goldstein's (2010) analysis revealed a low frequency of bi-directional transfer that occurred in the production of only two out of eight Spanish-English bilingual children, constituting 25% of their sample. These instances of transfer constituted the modification of low-level phonetic rules such as the aspirated stop consonants in English into unaspirated stops corresponding to the Spanish rule. In addition, Goldstein and Bunta (2012) documented three tokens of segmental transfer by two out of ten Spanish-English bilingual children. They found that only one of the children demonstrated bi-directional transfer.

Transfer is considered to be one of the manifestations of cross-linguistic interaction according to Paradis & Genesee's (1996) model. It is regarded as a qualitative measure while the other two manifestations are temporal notions because they are concerned with the time frame in which the linguistic structures are acquired in relation to monolingual acquisition (Lleó and Cortés, 2013). The following sections

will examine the evidence of acceleration and delay in the acquisition of bilingual children.

Acceleration

Paradis and Genesee (1996) proposed that certain grammatical categories emerge earlier in bilingual children's acquisition as a result of cross-linguistic interaction compared to monolingual development (p. 3). From this perspective, interaction could have a facilitative influence in which the saliency of a certain linguistic property in one language (L_a) could expedite its acquisition in the bilingual's other language (L_b), resulting in a faster rate of attainment relative to age-matched monolinguals of L_b. Support of this hypothesis has been observed across different linguistic domains such as syntax, semantics and phonology. The focus of this section will be directed towards phonological acquisition research.

Lleó *et al.* (2003) examined the phonological acquisition and development of coda longitudinally in five German-Spanish bilingual children and three monolingual children in each language. Their findings indicated that bilingual children's acquisition of coda is more accelerated than their age-matched Spanish monolinguals. This acceleration was expected since the complexity of syllable shapes in German and their high frequency of occurrence led to their early acquisition in Spanish. Moreover, the acquisition of the same property in Germany by the bilinguals seemed to be comparable to German monolingual peers. However, this was unpredicted since the authors hypothesized that coda development in the bilinguals would be lower than their German monolingual peers as a result of its lower frequency of occurrence in the Spanish language. Similar findings were observed by Lleó and Cortés (2013), in

which the acquisition of closed syllables is accelerated in Spanish language by bilinguals compared to monolinguals. They attributed the early acquisition of this entity to its high frequency of occurrence in Germany and its occurrence in both bilingual languages.

Faster rates of acquisition were also observed in the segmental acquisition of bilingual children. A large-scale cross-sectional study of ninety-three Maltese-English bilingual children was conducted by Grech and Dodd (2008). They reported that bilingual children have accelerated segmental production accuracy compared to their monolingual counterparts. They concluded that bilingual environment might have had a role in advancing phonological awareness of bilinguals, which led to a faster rate of acquisition than monolinguals. Similarly, Goldstein and Bunta's (2012) findings revealed that bilingual children demonstrate superiority in their accuracy of nasals compared to English monolingual children. Acceleration was also exhibited through a lower rate of error patterns compared to monolinguals. For example, MacLeod and Fabiano-Smith (2015) found that French-English bilingual (mean age 3 years) children produced lower error rates in terms of affricate allophones than French monolinguals. Therefore, it appears to be that the articulatory knowledge of affricate phonemes in English facilitated the acquisition of affricate allophones in French, resulting in acceleration of acquisition.

These studies demonstrated that cross-linguistic interaction in bilingual acquisition could be a facilitative mechanism resulting in a faster rate of acquisition of different phonological subcomponents compared to a monolingual acquisition. However, another aspect of interaction is assumed to hinder acquisition, which will be the focus of the next section.

Delay

The second hypothesis proposed by Paradis and Genesee (1996) is delay. They anticipated that the acquisition of two linguistic systems could be burdensome and therefore may result in a slower rate of grammatical development by bilingual children compared to their monolingual peers. It is important to point out that the concept of delay does not refer to late emergence of a particular linguistic property but to the overall rate of acquisition. However, this description was rarely implemented by scholars and was altered to refer to a slower rate of development of particular linguistic properties in comparison to monolingual norms. Fabiano-Smith and Goldstein (2010) objected to the use of the term delay as it may imply a state of impairment and instead referred to this hypothesis as deceleration. Different authors have followed their footsteps and adopted this terminology (Hambly *et al*., 2013; Prezas *et al.*, 2014). Evidence of this phenomenon is observed in different phonological categories, such as segmental acquisition and accuracy.

Slower rate of acquisition was demonstrated in the acquisition of both segments and allophonic rule. For example, Lleó and Cortés's (2013) study revealed cases of substantial delay for the acquisition of several entities, like spirants and assimilated nasals, in Spanish-German bilingual children compared to their monolingual peers. Moreover, the acquisition of long vowels in German and voiced stops by both languages underwent a short delay in acquisition but was soon overcome. In addition, allophonic rule acquisition was found to exhibit cases of delay by Spanish-English bilinguals. MacLeod and Fabiano-Smith (2015) investigated the rate of acquisition of the allophonic rules by three-year-old Spanish-English

bilinguals and their monolingual peers. The outcome of their study indicated that Spanish-English bilinguals produced higher error rates than Spanish monolingual children.

Another aspect of delay was observed in accuracy of production, in which it was observed to be higher in the production of monolingual compared to their age-matched bilingual counterparts. Goldstein and Bunta's (2012) study sought to examine and compare the speech accuracy of bilingual and monolingual children. Ten Spanish-English bilinguals (mean age 6 years), as well as ten monolinguals (mean age 5:10 years) in each language, were selected to participate in their study. The findings indicated that the bilingual children demonstrated lower accuracy rates of stop consonants than Spanish monolinguals, indicating delay in this area.

The discussion in this section focused on reviewing evidence of cross-linguistic interactions in current investigations pertaining to phonological acquisition. A great deal of variability has been observed in the rate and frequency of elements subject to cross-linguistic interaction. The aim of the next section is identifying conditions that could influence interaction.

1.2.2.2 Influential factors

Though the findings of the previously reviewed studies on phonological acquisition do not permit generalizability, they shed some light on possible consequences of language contact. Genesee and Nicoladis (2006) described these findings as tentative and argued that developmental patterns reported in phonological studies are more complicated than other linguistic domains, such as morpho-syntax and lexical bilingual acquisition. They attributed the inconclusiveness of normative

patterns to several factors: 1) heterogeneity of bilingual population, 2) scarcity of studies in various areas and 3) methodological shortcomings in research designs of phonological acquisition studies, such as single case studies or small population. Kehoe (2015) also acknowledged that these confounding findings are the outcome of the lack of an adequate research model. In addition to these shortcomings, the linguistic acquisition and development process is bound by multiple factors that shape the trajectory and rate of phonological development across bilingual children. Some of them are observed in monolingual's acquisition as well, which are related to maturational and individual characteristics. Others are exclusive to bilingual's acquisition, like language dominance as well as exposure, input, and transfer (Genesee & Nicoladis, 2006). Each of these factors and their implication to BFLA, with a specific focus on phonological acquisition will be discussed.

1. Linguistic domain

Research in a particular sub-linguistic field such as phonology and syntax could result in different findings and implications for the same phenomena in bilingual acquisition. Some studies found that bilingual linguistic systems develop autonomously without any interaction for one linguistic domain while interaction was observed in another domain. In her study, Paradis (2000) addressed morphosyntactic and phonological acquisition in French-English bilingual children. Her results suggested that there is evidence for cross-linguistic effect at the phonological level. However, this effect was not evident in her study addressing syntax development on children acquiring the same language combination. Therefore, it is suggested that language combinations interact differently at different language levels.

2. Language Dominance

Language dominance is a construct used broadly to refer to ‘the degree of bilingualism manifested by individuals who know two languages, that is, the relative level of proficiency in each of the languages’ (Hemàndez-Chávez *et al*., 2013, p. 41). Two types of bilinguals are identified within this notion: balanced and dominant. Balanced bilinguals are those who possess equal competence in both languages. Some scholars argue that identical competencies in both languages is rarely achieved (Treffers-Daller, 2010), and some propose the use of 'near-balanced bilinguals' to refer to comparable levels of competence in both languages. The other type in that categorization is dominant bilinguals. The dominant bilingual is one whose competence in one language is perceptibly higher than the other language. The more proficient language is usually referred to as the stronger language and projected to interfere in the acquisition of the weaker language (Grosjean, 1982).

The extensive use of the notion of dominance in bilingual literature arises from the need for measurable criteria of bilingualism. This need is crucial since bilinguals are not a homogenous population and a commonly accepted typology of bilinguals does not exist (Treffers-Daller, 2010). Some scholars use the construct of dominance as a measure for selecting and categorizing bilingual participants. Others use it in their analyses to account for occurrences of high-frequency rates of atypical structures. For example, Döpke (2000) suggested that language dominance could contribute to variations presented in the bilingual data, in which some cross-linguistic interaction was found to be systematic in some children while appearing rarely in the production of others. Genesee *et al.*'s (1995) study concluded that language

dominance was the main influential factor attributed to any language mixing in the bilingual production. In addition, Paradis (2001) considered language dominance to be a crucial factor in determining the directionality of interaction. In her post-hoc consideration, she divided English dominant and French dominant bilingual children in two groups and excluded balanced bilinguals. She found that language dominance is a factor in determining the directionality of cross-linguistic effect rather than cross-linguistic structural differences. She called for the consideration of language dominance as a significant variable in future studies.

Though the construct of dominance could be of great use in terms of categorizing the bilingual population, other scholars have widely disputed its use on several grounds. DeHouwer (1998) pointed out the vagueness surrounding the definition in which it is defined through proficiency. She questioned the validity of using two different phenomena that could be measured independently to define each other. This lack of clarity could be attributed to the nature of dominance as an abstract construct that encompasses several components, such as proficiency, fluency, and frequency. Another issue is its dynamic characteristics that fluctuate longitudinally. Its dynamic nature makes it susceptible to any changes that occur in the bilingual linguistic and cultural environments (Harris *et al.*, 2006). In addition, different linguistic domains could also display variability in dominance patterns where, for example, the bilinguals exhibit dominance in Language A in syntactic but display dominance in Language B in phonology (Bedore *et al*., 2012).

Another controversial term associated with language dominance concerns its measurement. Several approaches have been deployed to assess language dominance, ranging from self-, parent-, and caregiver-report questionnaires and interviews of language exposure and current use (Marchman & Martinex-Sussmann, 2002;

Gildersleeve-Neumann *et al*., 2008; Goldstein *et al.*, 2010; Bedore *et al.*, 2012; Mayr *et al.,* 2015). Additionally, objective measures are applied, including a variety of language proficiency screening tests (Flege *et al.*, 2002; Treffers-Daller, 2010). This variability in quantifying the same construct could potentially lead to discrepancies in research outcomes and impact the generalizability of the findings.

The controversy associated with the dominance construct in the literature in terms of how it is defined and measured could explain the variability that exists in the literature's findings. The next section discusses other factors that are claimed to influence the directionality of interaction.

3. Cross-linguistic structural differences

Different language combinations could have acceleratory or inhibitory effects on the process of language acquisition and development. Diversity in the field was attributed to different language combinations. Skinka (2000) claimed that differentiation and autonym of linguistic systems are promoted by the languages to which bilingual children are exposed. Similarly, Döpke (2000) maintained that 'some language combinations generate greater structural ambiguities than others' (p. 5). Accordingly, different language combinations could influence the production of either systematic or episodic cross-linguistic structures. This diversity highlights the importance of studying the bilingual acquisition of different language combinations to arrive at a more coherent picture of bilingual development.

4. Input

Given that bilinguals are exposed to the linguistic inputs of two different languages, a wider range of possibilities are at their disposal in comparison to monolinguals, which could lead to confusion. Hulk (2000) argued that disambiguation is harder when the adult input in one language offers cues for an erroneous analysis of the other language' (p. 75). Paradis (2000) stated that when bilinguals are faced with ambiguous input they adopt strategies in their dominant language to overcome such difficulties. Accordingly, bilinguals are dealing with even more demanding tasks in discerning two different sets of inputs than monolinguals who deal with one system, which makes bilingual acquisition a more arduous task. Scholars investigated the association between parental input and mixed elements in their bilingual children production. While Genesee *et al.* (1995) did not find a link between parental mixed input and their children code mixing, Khattab (2002) found that bilingual children's production of /l/ in Arabic reflected some of the phonological features of their parents and was not evidence of interaction. She argued that some researchers falsely assumed that mixed elements are the result of linguistic interaction; however, it is the result of the input to which these bilinguals are exposed.

5. Individual variations

Discrepancies in early phonological development were attested among monolingual as well as bilingual children. However, these differences are more pronounced in the bilingual population due to additional factors such as lack of homogeneity in their proficiency cross-linguistically, Age of first arrival (AOA), and

structural differences across different language combinations. Nonetheless, it is possible for children with similar linguistic environments to demonstrate variability in their phonological acquisition trajectories. A study conducted by Schnitzer and Krasinski (1994) of their son and the later study of his sibling (1996) demonstrated divergence in the acquisition profile of two brothers learning the same language combination under comparable circumstances. Their findings supported different theoretical implications where the patterns of interference suggested that their first child had a unitary phonological system that later separated whereas their other child observed to differentiate his phonological systems from the onset of acquisition. It is hypothesized that bilingual children use different mechanisms to deal with the challenges they face whether it is input ambiguity or lack of proficiency in one language. These mechanisms are not compulsory and are deployed differently by children. Döpke (2000) argued that manifestations of cross-linguistic interaction are 'based on the child's momentary analytic capacities' (p. 5), even though they are only viewed as experiments. It, therefore, has an individual aspect, where some bilingual children may find greater utility in it than others. Therefore, inconsistencies in the literature could be attributed not only to theoretical and methodological issues but also to the complexity of the phonological acquisition process and the phenomena of interaction in particular. Providing detail account of the bilinguals' patterns of acquisition and development is essential to advance our understanding in this field.

1.2.3 Summary

In this chapter, I have strived to provide the theoretical basis for this current investigation by reviewing the major debates in the field of bilingual acquisition, with

close attention to phonological acquisition. The field is characterized in general by its lack of conclusiveness, which is partly due to theoretical and methodological inconsistencies. In the next chapter, I will outline the differences and similarities between monolingual and bilingual acquisition research and identify gaps in the literature.

2 Phonological Acquisition: Monolingual- vs. Bilingual-Speaking Children

2.1 Introduction

The structure of linguistic properties across languages was found to affect the trajectory of acquisition in monolingual as well as bilingual children. The effect of different language combination on cross-linguistic interaction has been documented as previously discussed. In this study, a segmental phonology approach was selected to establish the extent of interaction between the phonological systems of bilinguals. This approach is common in clinical linguistic studies that are usually used to provide information about the phonological development of children of the ambient language in the field of monolingual acquisition. It has also been used by researchers in the field of bilingual acquisition, mainly to explore the convergence and divergence between bilingual and monolingual phonological acquisition (Holm & Dodd, 1999; Fabiano-Smith & Goldstein, 2010). For this current investigation, this approach seems to be appropriate because of the need to quantify the longitudinal data to address the extent and frequency of interaction. It is a rigorous approach and is widely used in monolingual acquisition research, which will allow for further comparison between the acquisition pattern of the participants and that of other studies. This is crucial since the model chosen to establish the occurrences of cross-linguistic interaction is based on three hypotheses, two of which (acceleration and delay) are compared to monolingual acquisition norms. In addition, information about Percentage of Consonant Correct (PCC) segmental inventory and error patterns for typically-developing English/Arabic simultaneous bilingual children under the age of five does

not exist in the published literature. Thus, this investigation strives to add new empirical knowledge of the acquisition of bilinguals from this language combination, which has not received considerable attention.

In this section, I will start by reviewing the phonological properties of English and Arabic. These languages are considered typologically distant languages, as will be reviewed in the next section. After reviewing points of convergence and divergence of the phonological systems of the languages under consideration, a review of the norms in monolingual children phonological acquisition of these languages will follow. The aim is twofold: 1) monolingual data will be employed to form a baseline comparison to the findings of the current investigation and 2) recognizing any possible phonological ambiguity across these two languages that may be manifested as cross-linguistic interaction. After that, a thorough review of the current field of segmental consonant acquisition in bilingual children will be carried out to identify gaps in the literature.

2.2 Phonological systems of English and Arabic languages

English and Arabic are typologically distant languages; they have different writing systems as well as different inventory size for consonants and vowels. This section will start with a review of English followed by Arabic segmental system. A cross-linguistic comparison will follow.

2.2.1 English

The phonemic system of English consists of the following plosive consonants (see Table 2-1): /p, b/, /t, d/, /k, g/. It also includes three nasals /m, n, ŋ/, fricatives /f,

v/, /θ, ð/, /s, z/, /ʃ/, /h/, affricates /tʃ, dʒ/, lateral / ɬ, l/, glides /w, j/ and approximate /ɹ/. It is worthy to note that the phoneme /ɹ/ differs according to its phonetic realization and its distribution. These differences could be attributed to dialectical and contextual factors. Pre-vocalically, [ɹ] is realized as a voiced post-alveolar approximant (e.g. /ɹɪŋ/ ring), while it is usually replaced by the preceding vowel post-vocalically (e.g. /hɔːs/ horse) in non-rhetoric accents (Cruttenden, 2014).

	Bilabial		Labio-dental		Dental		Alveolar		Post-alveolar		Palatal		Velar		Glottal	
Plosive	p	b					t	d					k	g		
Nasal		m						n						ŋ		
Fricative			f	v	θ	ð	s	z			ʃ				h	
Affricate									tʃ	dʒ						
Approximant								ɹ								
Glides		w										j				
L. Approx.								l								

Table 2-1: English Phonetic Inventory (Roach, 2004)

The vowel system of British English is considered very rich (see Table 2-2), consisting of 20 vowels that include short, long and diphthongs (Cruttenden, 2014).

Type	Vowel
Short	/ɪ/, /e/, /a/, /ɒ/, /ʊ/, /ʌ/, /ə/
Long	/iː/, /ɛː/, /ɑː/, /ɜː/, /ɔː/, /uː/
Diphthongs	/eɪ/, /aɪ/, /ɔɪ/, /əʊ/, /aʊ/, /ɪə/, /ʊə/

Table 2-2: English Vowel Inventory

2.2.2 Arabic

There are many dialectical variations in the Arabic language. For the current study, the discussion will be limited to the Arabic dialect spoken by the participants' parents, which is known as the Eastern Saudi accent and bares close resemblance to the Arabic gulf region dialect. Below we will be discussing the phonological system of this dialect.

The phonemic inventory of the dialect of Arabic gulf region is rich (see Table 2-3), consisting of eight plosive consonants: bilabial /b/, dental /t, d/, emphatic /tˤ/, velar /k, g/, uvular /q/ and glottal /ʔ/; thirteen fricatives: labiodental /f/, interdentals /θ, ð/, alveolar /s, z/, emphatics /ðˤ, sˤ/, post-alveolar /ʃ/, uvular /χ, ʁ/, pharyngeals /ħ, ʕ/, /h/; two affricate Palatal /tʃ, dʒ/, nasal /m, n/, liquids, flap, trill /ɾ, r/, lateral approximant /l/, emphatic lateral /lˤ/ and two glides /j/, /w/.

	Bilabial	Labio-dental	Dental	Alveolar	Post-alveolar	Palat.	Velar	Uvular	Pharyng.	Glottal
Plosive-	b			t d			k g	q		ʔ
Emphatic				tˤ dˤ						
Nasal	m			n						
Trill				r						
Tap or Flap				ɾ						
Fricative-		f	θ ð	s z		ʃ		χ ʁ	ħ ʕ	h
Emphatic			ðˤ	sˤ						
Affricate					tʃ dʒ					
Glides	w					j				
L. Approx.					l					

Table 2-3: Arabic Phonetic Inventory (adapted from Hassan & Heselwood, 2011)

There are variations in the realization of some phonemes. For example, the phone /r/ is realized as either a tap [ɾ] or a trill [r] alveolar, which is determined mostly by its phonological context in the word. The realization of /r/ as a tap or a flap depends on whether it is a single /r/ or a geminate, in which /r/ is produced as a tap [ɾ]

or a trill [r] respectively. The difference between these two realizations is greater than the difference of their manner of articulation; it could also change their lexical meaning: An example of a single tap is [baɾa] 'he sharpened' and for the same word but with a geminate trill [barːa] 'outside' (Khattab, 2002a, p. 94). However, there seems to be some contextual and dialectical variation in which a trill could be single and a geminate can be realized as a tap (Khattab, 2002a).

In addition, the emphatic plosive /dˤ/ is realized as emphatic fricative [ðˤ] in Gulf Arabic. For example, /jədˤɾɛb/ 'he hits' is pronounced as [jəðˤɾɪb] by adults. Moreover, uvular /q/ could be realized as the velar [g] in some positions or words; however, educated speakers usually attempt to refrain from using it in formal contexts. For example, the acceptable pronunciation of 'pen' is [gəlˤɑm]; nonetheless, speakers with higher education usually pronounce it as /qəlam/, which is equivalent to formal Arabic.

Arabic consonantal inventory is considered very large compared to other languages; however, this is not the case for its vowel inventory (Watson, 2002). The vowel inventory of classic Arabic consists of short vowels, long vowels, and diphthongs. Moreover, vowel inventories vary across Arabic dialects. Therefore, we will only discuss the vowel system of Eastern Saudi Arabic, as it is the dialect of the participants of this study. The Eastern Saudi dialect is similar to that of its neighbouring Kuwaiti dialect, which consists of 14 vowels including short, long and diphthongs.

Type	Vowel
Short	/a/, /i/, /u/, /ɑ/, /ə/, /e/
Long	/aː/, /eː/, /iː/, /oː/, /uː/

Diphthongs	/aw/, /ay/, /iy/

Table 2-4: Arabic Vowel Inventory (Al-qenaie, 2011; Watson, 2002)

2.2.3 Cross-linguistic comparison between English and Arabic phonological systems

Arabic and English languages have very different phonological and morphological structures (see Table 2-5). The phonological inventories of the two languages overlap in terms of some consonants (e.g. /b, d, k, t, f/) and syllable shapes (e.g. CV, CVC). However, Arabic includes several additional consonants, such as the emphatic consonants /tˤ, dˤ,ðˤ, sˤ/, voiceless uvular stop /q/, glottal stop /ʔ/, voiceless and voiced uvular fricatives /x/ and /ɣ/ and voiceless and voiced pharyngeal fricatives /ħ/ and /ʕ/ (Amayreh & Dyson, 1998); on the other hand, Arabic excludes the voiceless stop /p/ that occurs in English. While English and Arabic phonological inventories both include the phoneme /r/, its phonological characteristics varies across and within these languages. Arabic /r/ has a quality that is also encountered in other languages; Parisian, for example (Watson, 2002). The post-alveolar approximant /ɹ/, alternatively, is quite unique to English in that it shares some features with vowels (Cruttenden, 2014). Another difference could be viewed in terms of English /ɹ/ distribution, which could be omitted post-vocalically, while the Arabic /r/ retains its presence in all contexts (Khattab, 2002a).

In addition, both languages have two different varieties of the lateral /l/ sound. The first is clear, which characterizes most of its realization in Arabic with few exceptions (Khattab, 2002). The production of clear [l] is assumed to be of a simple segment involving one controlled lingual gesture, tongue tip only (Recasens, 2004, p. 594). On the other hand, words containing the name of god (e.g. ɑlˤlˤɑh) and

derivatives are pronounced with emphatic or pharyngealized [lˤ] variety (Watson, 2002). Moreover, an emphatic environment may influence the pronunciation of [l], causing it to be produced with more emphatic quality [lˤ] if it followed by a back vowel (e.g. ðˤɑlˤɑm). Arabic emphatic or pharyngealized [lˤ] is a complex segment involving the co-occurrence of many lingual gestures (tongue retraction, spreading or raising, lip protrusion, pharyngeal constriction) (Khattab, 2002, p. 339). English /l/, on the other hand, whether positioned at onset /l/ or at the coda /ɬ/, involves the activation of two independently controlled gestures: tongue tip rising and tongue post-dorsum retraction (Recasens, 2004). However, the main distinction between the clear and dark [l] varieties has to do with the raising of the back of the tongue toward the soft palate, giving dark [ɫ] a velarized or pharyngealized quality (Cruttenden, 2014). The main distinction between the dark varieties of /l/ in both languages is that in Arabic the allophonic distribution rule is absent while in English language /l/ distribution is governed by an allophonic rule sensitive to the phonological context.

	English*	Arabic
Vowels and diphthongs	20	14
Consonants	24	31
Language-specific phoneme	/p/, /v/, /ɹ/ /ŋ/	/tˤ/, /q/, /ðˤ, sˤ/, /χ, ʁ/, /ħ, ʕ/ /ɾ, r/
Clusters	49	
Syllable shapes	$C_{(0-3)}VC_{(0-3)}$	$C_{(1-2)}VC_{(0-2)}$
Stress	Complex	Complex
Word length	Many multi-syllabic words	Many multi-syllabic words

Table 2-5: Characteristics of English and Arabic phonology (*adapted from Dodd *et al.*, 2006)

2.3 Monolingual and bilingual phonological acquisition

The aim of this section is to examine and identify the commonalities and differences between monolinguals' and bilinguals' phonological acquisition patterns and behaviours. The reviewed literature included studies of children aged between two and four years old. In the monolingual section, two languages were selected: Arabic and English. Only large normative cross-sectional studies were selected to best identify the age of acquisition of consonants and error patterns within the age range specified. This distinction will serve as a comparison ground to findings of bilingual acquisition. A comparison between Arabic and English children's phonological acquisition patterns will follow. For the bilingual section, the literature lacks any large-scale studies except for Grech and Dodd (2008). Recent studies of bilingual phonological acquisition were selected to address current theoretical questions of cross-linguistic interaction between the bilingual phonological systems of children aged between two and four years old.

2.3.1 Monolingual acquisition

English and Arabic are typologically distant languages, which make them great candidates for a cross linguistic-comparison. Differences and similarities across the developmental data of these languages will further our knowledge of universal and language-specific patterns.

2.3.1.1 Phonemic inventory

English

Table 2-6 illustrates the age of phoneme acquisition across four studies conducted in English monolingual children in Britain, the United States, and Australia. Each study will be reviewed in detail, followed by a summary of the findings.

Smit *et al.* (1990) reported normative data on 997 children from two states, Iowa and Nebraska, in the United States. The participants ranged in age from three to nine years and were divided into ten different age groups. Children were drawn from representative socioeconomic backgrounds in the two states, and only those who speak a Midwestern dialect were included. A single-word instrument was used for data collection and tested singleton production in word-initial and final-positions, excluding /ʒ/ and /- ð/ and with the addition of intervocalic /r, l/ as well as most word-initial clusters. Sound assignment to an age level required acquisition by 90% of children in word-initial and finals. Findings reported by the authors indicated that their socioeconomic background had no influence on the phonological acquisition of children; however, they noted that gender had an effect on age of acquisition. Girls were found to acquire sound elements such as /j-, d, θ, ð-, ʧ, ʤ, ʃ, l/ earlier than boys, while boys acquired the sounds /t, n/ before girls. However, it is worthwhile to note that these differences only reached statistical significance for age six and younger.

Parther *et al.* (1991) investigated the phonological acquisition of 147 children, ranging in age from two to four years and from representative socioeconomic backgrounds. Consonants were tested in the initial and final positions of 44 pictures

selected from articulation tests. Assignment of a sound to an age level required its acquisition by 75% of children in an age group. The authors concluded that their findings revealed considerably younger age of sounds acquisition in comparison to earlier studies. This result could be explained through the less stringent criteria the authors used in comparison to other studies.

A large-scale study by Dodd *et al.* (2003) included 684 children aged three through six, eleven of whom were recruited from different parts of the United Kingdom. Normative data were obtained in order to establish the age of sound acquisition and error patterns. The authors attempted to look at the prospect of age, gender and socioeconomic status on the speech sound development of these children. Two measures were used for data collection: articulation and phonology assessments. The articulation assessment was directed to establish the age of acquisition, while the phonology assessment attempted to establish the extent of error patterns in the participants' speech production. They concluded that the effect of gender was only observed in the accuracy of the older group with girls being more accurate. In addition, socioeconomic status did not bear any significance on the speech sound development of these children. Table 1 summarises the age of acquisition, while Table 2 recounts error patterns.

McIntosh and Dodd's (2008) study examined the speech production of 62 English monolingual children aged between 2; 1 - 2; 11. Their aim was to provide a normative data of these children's phonetic repertoire and error patterns. Data was collected by the toddler phonology test TPT; both spontaneous and imitated responses were included. Ten of the children were further assessed until they reached three years old. The purpose of the longitudinal case studies was to examine the ability of these tests to predict atypical phonological disorder at two years old. The authors

concluded that qualitative results seem to be a valid measure in predicting atypical phonological disorder, unlike the quantitative data. In addition, they acknowledged the extensive articulation skills of two-year-old children, in which their phonetic repertoire included stops, nasals, lateral approximant and some fricatives (see Table 2-6). It is crucial to point out that their test did not include the phone-segments /ð, ʒ, v/; therefore, it is not clear whether they are missing from these children's phonetic repertoire as a result of measuring procedure or due to lack of acquisition.

	Smit *et al.* (1990)	(McIntosh & Dodd, 2008)		Parther *et al.,* (1991)	(Dodd *et al.*, 2006)
Word positions	I, F	I, F		I, F	I, F
Sample size	997	62		147	684
Age group	3;0 - 9;0	2;1 - 2;11		2;0 - 4;0	3;0 - 6;11
Criteria	90%	90%	75%	75%	90%
PCC		2;0-2;5(63.9%) 2;6-2;9(73.3%)			3;0-3;11(82%)
Early sounds (2;0-2;11)		/p, b, t, d, k, g/ /s/ /m, n, ŋ/ /w, j, h/	/p, b, t, d, k, g/ /s, z, f/ /m, n, ŋ/ /w, l, j, h/	/p, b, t, d, k/, /f/ /m, n, ŋ/ /w, j, h/	
Intermediate sounds (3;0-3;5)	/m, n^m/, /w, h/, /p, b, d^f,			/g/,/s/, /l/, /ɹ/	/p, b, t, d, k, g/, /m, n, ŋ/ /f, v, s, z, h/
(3;6 - 3;11)	/n^f/, /$t^{m/}$, /d^m/, /k, g^f/, /f-/			/ʃ/, /ʧ/	/w, l-, j/
Late sounds (4;0- 5;11)	, /v/, $ð^f$-, /g^m/, l-, /j/, /t^f/, /-f/			/v, z, θ, ð, ʒ/, /ʤ/	/ʧ, ʤ / /ʃ, ʒ,
Very late sounds <6;00	/ɹ/, -l, ʤ, /ʧ/, /ʃ/, z, s, $ð^m$-, θ, /ŋ/				/ɹ/, θ, ð /

Table 2-6: Age of phoneme acquisition by English speaking children

Table 2-6 displays age of phonemes acquisition reported by different studies. There are some consensus and differences of establishing the age of acquisition of different sounds. To some extent, Parther *et al.* (1991) and McIntosh and Dodd (2008) reported similar patterns of articulation development of young children aged between two and three years old. After that, reported age of acquisition seems to vary in the three studies reviewed. The major differences involve the late appearances of the fricatives /ʃ, z, s/, the affricate /ʤ, ʧ/, and the nasal /ŋ/ by Smit *et al.* (1990) in comparison to the other studies. The discrepancies in the findings of the examined studies may be attributed to several factors. First, these studies reported two varieties of English: American and British. Second, differences in data collection procedure, sampling and analysis could also account for some of the variation reported. In the next section, we will examine normative studies of Arabic children.

Arabic

The number of studies on Arabic phonological acquisition had increased in recent years. The need for reliable normative data to assess speech pathologists in their diagnosis of language disorders was one of the gaps that prompted interest in this field. In the past, language therapists relied on universal acquisition patterns in assessing language disorders of Arabic children. The other challenge that language therapists faced was the dialectical variation of the Arabic language. Arabic is spoken in a wide range of countries, with each holding special characteristics. This variety intensified the need for studies to address different dialects. The most commonly published researched dialects appeared to be Egyptian and Jordanian. Little is known about the phonological acquisition of Arabic speaking children living in the Gulf

region because investigations into the acquisition of this dialect may have been conducted in Arabic or were unpublished. Below, I will try to establish the similarities and differences of major Arabic phonological development studies. The main criteria for selecting these studies were the focus of these studies as well as the age range of the participants.

Amayreh and Dyson's (1998) study sought to determine the age of acquisition of sounds and their accuracy of production by Arabic-Jordanian speaking children. The participants consisted of 180 normally-developing children aged between 2 to 6;4 years old, with an equal number of females and males in each age group. A 58-picture articulation test was used for data collection. The acquisition criterion of a phoneme was defined by 75% accuracy of production by children in a given age group. Consonants were grouped into three categories according to age of acquisition: early (before 4), intermediate (between 4;1-6;4) and late (over 6;4). The findings indicated shared trends between Arabic children acquisition and English monolinguals and universal trends. Moreover, language-specific patterns were also detected. Table 1 summarises their findings

A follow up study by Dyson and Amayreh (2000) was carried out to investigate error patterns used by typically-developing Arabic monolingual children aged two to four (n=50). The same articulation test was used for their data collection as in their previous study (Amayreh & Dyson, 1998). The researchers accounted for the deviation of the Arabic ESA targets even though adult-like substitutions were not considered as errors. The differences between ESA and local dialects are one of the major challenges that children face when entering school. The researchers' attempted to account for these differences and challenges, which may be informative for teachers. Teachers could include focused activities addressing the most difficult ESA

consonants. Nonetheless, their findings may not be very relevant to speech pathologists, as children this age are not exposed to ESA. For a summary of their main findings, refer to Table 2-7.

A cross-sectional study of 160 normally-developing Syrian children aged between 2;6-6;5 was carried out by Owaida (2015). Data was collected via a picture-naming test designed by the author to identify the age of acquisition of phone-segments and error patterns. Most vowels were reportedly acquired before the age of three, while all consonants were acquired by 6;5 years old, except for /ʒ/. The order of Syrian children's consonant acquisition pertaining to manner of production was described to ascend from the approximant> nasals > plosives > /l/ > fricatives > to trill. In addition, twelve error patterns were identified in the speech of these children: r-deviation, fronting, stridency deletion, de-emphasis, de-affrication, weak syllable deletion, stopping, backing, glottalization, devoicing, and assimilation. The production of error patterns decreased over time and ceased by the age of 5;5 years old.

A study with a smaller sample size was conducted by Alqattan (2015). It attempted to account for the phonological development of Kuwaiti Arabic children. The sample consisted of 70 normally-developing children aged between 1;4 to 3;7 years old. A cross-sectional design was deployed, and data collection methods consisted of spontaneous speech samples acquired via 30 minutes of video and audio recordings of children interacting with their parents. The author found discrepancies between error patterns produced by Arabic children and those of English children reported in the literature. The findings of the study are summarized in Table 2-7. She concluded that the rate and order of consonant acquisition could be predicted partially by their frequency in the input of the ambient language.

Language	Alqattan (2015)	Owaida (2015)	Amayreh & Dyson (1998)[1] & Amayreh (2003)[2]
Word positions	I, M, F	I, M, F	I, M, F
Sample size	70	160	180(1) 60(2)
Age group	1;4 - 3;7	2;6 - 6;5	2;0 - 6;4(1) 6;6 - 8;4(2)
criteria	90%	90%	75%
Early sounds (<2;0-2;11)	/k, ʔ/ /m/	/b, d, t, ʔ/ /m, n/ /f, h/ /l, w, j/	/t, k,/ /m, n/ /f / /w/ /ħ/
Intermediate sounds (3;0-3;5)	/p, b, t, d, g/ /n/ /f, s, h/ /l, w/	/ s, z, ħ, ʕ/	/b/, /d/,
(3;6 - 3;11)			/l/
Late sounds (4;0-6;00)		/k/, /ʃ/,/ɾ/ /dˤ, tˤ, sˤ, ɣ, X/ ,	χ, s, ʃ , r, h, ʁ, j
Very late sounds (>6;1)			ð, dˤ, tˤ, q ʤ, ʔ, θ, ðˤ, z, sˤ, ʕ/
PCC	2;4-2;7: 61% 3;0- 3;3 : 78.6% 3;4-3;7: 80.7%		

Table 2-7: Age of phoneme acquisition by Arabic speaking children

Table 2-7 exhibits the findings across the three studies that examined the phonological repertoire of Arabic children aged between 1;4 and 6;5. Consensus was seen in the age of acquisition of emphatics that were reported as late acquired sounds. Stops, nasals and glides were acquired before four years old. Meanwhile, the different criteria used to determine the age of acquisition could affect the findings. For example, Amayreh and Dyson (1998) used a 75% accuracy criterion, while other

studies included both 75% and 90% accuracy percentage. Moreover, the previous study classified the segmental acquisition into three categories according to age of acquisition: early, intermediate and late. This classification is standard; however, they considered phonemes acquired before the age of four as an early acquired sound. This classification measure is problematic in identifying the sequential development of most phonemes, since children posses a large phonemic inventory at this age. Moreover, the leap in phonological acquisition is documented between children under and over three years old. Therefore, merging these two groups into one category may disregard major trends of phonological development patterns. Another methodological concern is in the discrepancies of data collection methods. Both Amayreh and Dyson (1998) and Owaida (2015) used picture naming tests, while Alqattan (2015) used a free speech sample. Subsequently, different methods stimulate different responses by participants; therefore, discrepancies in age of acquisition could not necessarily be attributed to dialectical difference only since the data collection methods differ greatly. Moreover, it is important to point out that limitations inherited in some of the reviewed data collection methods. For example, in free speech, children's inventory may consist of limited segments depending on the size of the child's lexicon and may not a true reflection of the participant's phonological repertoire. On the other hand, articulatory tests or picture naming tasks vary and thus pose challenges for comparison. Moreover, children may resist pronouncing some of the words, which could affect the result of setting the age of acquisition. Another concern in cross-sectional design is associated with determining the age of phoneme acquisition. In this approach, children are divided into groups according to their age. This categorization does not address variability between children, which could affect the findings. For example, a younger age group repertoire

is reported to be larger than an older age group in normative studies this poses a challenge when comparing and synthesising acquisition norms across different cross-studies.

Cross-linguistic difference in age of phoneme acquisition between English- and Arabic-speaking children

Table 2-8 illustrates the differences of phonemic acquisition across English and Arabic. Similarities and discrepancies could be the due to phonological and phonetic differences between the two languages, among other factors such as sampling and evaluation criteria. For the purpose of comparison, age of sound acquisition is assigned based on its occurrence in at least two reviewed studies of a particular language. An exception is made for the late acquired sound in which the findings were derived from one study. It is important to note that dialectical differences may have played a role in assigning the phoneme age of acquisition with a language.

Several consonants were observed to be acquired by similar age groups across the two languages. These sounds are the nasals /m, n/, stops /t, k/, fricatives /s, ʃ, θ, ð/ and the glide /w/. Sounds that were reportedly acquired earlier by English-speaking children are stops /b, d/, fricative /z/, glide /j/, glottal /h/, and affricate /ʧ, ʤ/, while the following sounds were acquired earlier by Arabic compared to English monolingual children: fricative /f/, lateral approximant /l/ and tap or flap alveolar /ɾ/.

	English	Arabic
Early sounds (2;0-2;11)	/m, n, ŋ/ /p, b, t, d, k/ /w, j/ /h/	/m, n/ /f/, /w/ /k, ʔ, t/
Intermediate sounds (3;0- 3;5)	/g/, /s/, /f/,	/b/, /d/, /s/, /l/, /h/, /ħ/,
(3;6 - 3;11)	/l-/	
Late sounds (4;0-5;11)	/ʧ, ʤ/ /ʃ, ʒ, v, z/	/X, ʁ/, /ʃ/, /ɾ/, /j/
Very late sounds (>6;0)	/ɹ/, /θ, ð/	/ʕ, dˤ, tˤ, sˤ/, /z/, /θ, ð/, /ʤ/, /q/

Table 2-8: Age of phoneme acquisition across English and Arabic

2.3.1.2 Error patterns

In general terms, an error pattern is recognized as the 'consistent differences between child and adult realizations' (Zhu, 2006, p. 20). In more specific terms, it is a 'general tendency that affects a group of sounds' (Dodd *et al.*, 2006, p. 32). Error patterns are also referred to as phonological processes, which are defined as a ‘set of mental operations that change or omit phonological units as the result of the natural limitations and capacities of human vocal production and perception’ (Dodd *et al.*, 2006). Even though both terms refer to the same concept of describing the deviation of child production from adult targets, some researchers avoid using the term 'phonological process' because it was criticized for its lack of explanatory power and to avoid any associated theoretical assumptions (ibid). In this thesis, I will refer to this process as error pattern to avoid any possible pejorative connotation.

Age	2;0-2;5		2;6 -2;11		3;0- 3;5		3;6- 3;11	
Language	E	A	E	A	E	A	E	A
1. Substitution error patterns								
a. Place								
Fronting	U	J	UA	JS	BA	JS	BA	S
Backing						S		S
Dentalization				S		JS		J
b. Manner								
Stopping	U	JK	UA	JK	BA		A	
Spirantization		J		J				
Gliding	U		UA	S	BA	S	BA	S
De-affrication	U		UA	K	B		B	
De-emphasis		JK		JKS		KS		KS
Stridency deletion		J		J				
Lateralization of /r/		JK		JK				K
Glottalization		J		JS		S		
2. Assimilation								
De-voicing	U	JK	U	JKS		JS		JS
Voicing								
3. Syllable error patterns								
Final consonant deletion (incl. coda deletion)	U	K	UA		A		A	
Cluster reduction	U	K	UA	K	BA		BA	
Weak syllable deletion	U	J	U	JS	B	S		S

Table 2-9: Reported error patterns across English and Arabic speaking children
U: Australian-English, B: British-English, A: American-English (Roberts *et al.,* 1990)
J: *Jordanian-Arabic, K: Kuwaiti-Arabic, S: Syrian-Arabic. (*adopted from Alqattan, 2015)

English

Table 2-9 reveals the development of error patterns across four different age groups, aged from 2-years-old to 3;11-years-old, as reported by phonological acquisition research of English-speaking children (Roberts *et al.*, 1990; Dodd *et al.*, 2006; McIntosh & Dodd, 2008). Some differences could be observed between these studies in the assignment of an error pattern to an age group. Convergence was found for fronting, gliding and cluster reduction among all age groups while stopping, deaffrication and final consonant deletion was commonly reported for children aged

between 2;6 and 2;11. In addition, some error patterns were shared among the four groups: fronting, gliding, de-affrication and cluster reduction. Other error patterns appeared to decrease in frequency after children turned three years old, such as devoicing and coda deletion, while stopping and weak syllable deletion error occurrences declined after age 3;6-year-old

Arabic

A quick review of Table 2-9 indicates that only two of all the error patterns are shared across the three studies for Arabic children between the age group of 2;0-3;11. These errors are de-emphasis and lateralization. The discrepancies of the reported error patterns could reflect the following: 1) the studies reviewed in this section reported the findings in two languages. Within each language, dialectical variation dictates what is considered as an allophonic variation of a particular sound or an error. 2) Differences in the categorization of the same error pattern; for example, in Owaida's (2015) study, /r/ deviation error pattern included lateralization and /r/ omission, while other studies categorized /r/ errors differently and included them under lateralization of /r/. 3) Inclusion criteria; in other words, the number of error occurrence to be considered as an age-appropriate error.

The discrepancies reported in the Arabic literature in defining the age of acquisition of segmental inventory as well as error patterns makes it difficult to synthesize these studies for monolingual comparison. Therefore, Alqattan's (2015) normative data will be used as the main reference for comparison to the findings of the current study. This study was chosen because of its dialect's close resemblance to the dialect of the participants in this study.

Differences between English- and Arabic-speaking children in error pattern production

Even though the phonology of the ambient language could have a direct influence on the type and frequency of error patterns, there are some universal trends that are shared among most languages. Below is a review of cross-linguistic comparison of error patterns across English and Arabic-speaking children.

A. Shared error patterns

Table 2-9 illustrates error pattern production across English- and Arabic-speaking children. Some of the errors are common between the two languages; however, they resolve at different time frames. Shared errors are fronting, stopping, gliding, devoicing, deaffrication, final consonant deletion, cluster reduction and weak syllable deletion.

B. Language-specific error patterns

Other errors were only identified in the speech production of Arabic speaking children. These errors are dentalization, spirantization, de-emphasis, stridency deletion, lateralization of /r/ and glottalization. The discrepancy between the two languages could be attributed to differences across the phonology of the ambient language. Another reason could be the results of methodological limitations, such as sampling procedures or differences in error pattern classification. In addition,

identification criteria for error pattern vary across reported studies (Table 2-10). For example, the average number of error pattern occurrences to be identified as age-appropriate is 10% of possible opportunities by most investigations. More stringent criteria were used by Roberts *et al.* (1990), which required at least 20% frequency score of possible opportunities. In contrast, McIntosh and Dodd (2008) identified an error pattern if it only occurred twice in different lexical items. These discrepancies in criteria used by different scholars produced inconsistent findings, which challenge possible attempts of synthesis of findings.

Study	Identification criteria for age-appropriate error pattern
Roberts *et al.* (1990)	The frequency of an error in at least 20% of total number of opportunities
Dodd *et al.* (2006)	Frequency of an error of at least 5 times and its occurrence in the speech production of at least 10% of an age group
McIntosh & Dodd (2008)	The production of the same error pattern in two different lexical items
Dyson & Amayreh (2000)	The frequency of an error in at least 5% of total number of opportunities by children in an age group
Alqattan (2015)	The frequency of an error in at least 10% of total number of opportunities by children in an age group
Owaida (2015)	Frequency of an error of at least 5 times and its occurrence in the speech production of at least 10% of an age group

Table 2-10: Identification criteria for error patterns across monolingual studies in English and Arabic languages

2.3.2 Bilingual acquisition

A consensus among bilingual studies is less established than monolingual acquisition research for several reasons. Watson (1991) discussed the challenges that scholars face when attempting to investigate phonological acquisition behaviours of bilingual children. In his argument, he stated that phonological acquisition literature is

scarce even for monolingual children, which is found to be less comprehensive in comparison to other linguistic domains in the literature. He identified four tasks that faced children attempting to learn any phonological system of their language (p. 27):

1. Learn to recognize distinct, but non-invariant acoustic patterns.
2. Deduce the set of oppositions, which constitute the phonological structure of the language.
3. Associate the acoustic patterns with the phonological system, despite the non-invariances of the former.
4. Master the correct articulatory routines to produce acoustic patterns, which satisfy other native speakers as being adequate realizations of different phonemes.

Accordingly, a monolingual child acquiring a single phonological system is confronted with series of complicated tasks before being able to construct the phonological system of the ambient language. This task is even more challenging for bilingual children, where they are faced with a larger and more variant mass of acoustic input that they need to discriminate and organize into two distinct phonological systems.

These differences between bilingual and monolingual acquisition explain the demanding task that any research in bilingual phonological acquisition could encounter. The absence of a conceptual framework for investigating bilingual acquisition challenges any attempt to reach an informed understanding about how bilingual children acquired their phonological systems. In addition, theoretical questions and assumptions about bilingual acquisition keep evolving, adding to the difficulty of synthesizing the findings into an expedient knowledge base. Keeping

these shortcomings in mind, the purpose of the following literature review is to re-examine recent studies investigating the consonant segmental acquisition of pre-school children beyond the one-word stage. This review is limited to recent investigations of bilingual pre-school children that follow the current conventional stance in the field.

2.3.2.1 Phonemic inventory

The paucity of research on bilingual children's typical phonological acquisition has been widely acknowledged by different scholars (Gildersleeve-Neumann *et al.*, 2008; Fabiano-Smith & Barlow, 2010). Table 2-11 summarises the findings of six studies investigating the sound acquisition of bilingual children aged between two and four years old. The findings indicated that bilingual children demonstrate qualitative and/or quantitative differences in acquisition's trajectory of their two languages. In addition, some research demonstrated differences and similarities between bilingual and monolingual acquisition for different measures. For example, Fabiano-Smith and Barlow (2010) revealed that the inventory complexity of bilingual children commensurate to that of monolingual children; however, at the same time bilinguals' PCC scores appeared to be lower than monolinguals' on certain classes. Below, we will review each study in detail.

Some studies indicate that bilingual and monolingual acquisition could demonstrate convergence or divergence depending on the measure used. Gildersleeve-Neumann *et al.* (2008) investigated the phonological acquisition of 23 Spanish-English bilingual children and 10 monolingual English children aged from 3;1 to 3;10. The study reported on phonetic inventory, phoneme accuracy and error

pattern frequency of the bilingual children and English monolinguals at two points in time, with an eight-month gap. The results show that the phonetic inventories' complexities are comparable across all children. Longitudinally, all groups demonstrated a steady decline in some error patterns. In addition, significant differences were observed between the balanced bilingual and English dominant bilingual children in error pattern frequency. English dominant bilingual children were observed to produce less frequent error patterns than their age match balanced bilingual peers. The authors concluded that exposure to two languages may have resulted in higher error pattern frequency due to interaction. The higher rate of error pattern compared to monolingual should be viewed as a typical process of bilingual phonological development at that age. The longitudinal effect showed that the bilingual group with sufficient language exposure was expected to reach adult-like production over time. It is important to note that the authors did not compare bilingual acquisition with Spanish monolingual children. This step is crucial because any comparison that fails to account for one of the bilingual children's languages may result in misleading conclusions.

Fabiano-Smith and Barlow (2010) sought to account for the phonetic inventory typology of eight Spanish-English bilinguals and their eight matched monolinguals in both Spanish and English (aged three to four years old). Similar to the findings of Gildersleeve-Neumann *et al.* (2008), the analysis revealed that the complexity of bilingual children inventories commensurate to their monolingual peers. However, the accuracy of production of certain manner classes observed by bilingual children seems to be lower than the monolingual participants but within the normal range of monolingual acquisition. Moreover, bilingual's phonetic inventories across their languages were not identical in terms of the hierarchy of phonetic

distinction, providing evidence of differentiation between their two phonological systems.

Other investigations reported an advanced level of phonological acquisition by bilinguals compared to their age-matched monolinguals. For example, in a large cohort study of 96 Maltese-English children and 137 of their age-matched Maltese children (aged between two and six years old), Grech and Dodd (2008) reported the children's accuracy of production and their error patterns among other measures. The findings indicated that phonological competence of children increased over age range. In addition, the data showed that bilingual children's PCC was higher than their age-matched Maltese group and was also higher than English monolingual children living in the United Kingdom, the United States and Australia. In terms of error patterns observed, the analysis showed a decrease of error patterns over age range. The bilingual group and monolingual group shared many patterns up to age four. After four years old, the differences between the groups significantly increased, with fewer error patterns observed in the bilingual group. The authors concluded that exposure to two languages could have a positive effect in stimulating learning and discriminating between phonological systems, resulting in the accelerated acquisition of their phonological competence on many levels.

Different trajectories of acquisition within different bilinguals' populations were attributed to differences in language dominance. Law and So (2006) investigated the role of language dominance in the phonological acquisition of 100 Cantonese-Putonghua bilingual children aged between 2;6 and 4;11. The authors used a phonology test in both languages, comprising picture-naming task and storytelling, to measure PCC and error patterns' frequency. The findings indicated that across the Cantonese and Putonghua dominant children, PCC in Cantonese production was

higher than PCC in Putonghua. The authors attributed this result to the simplicity of Cantonese consonantal system in comparison to Putonghua's. Moreover, the data showed that dominance influenced the rate of acquisition of the dominant and less dominant language. Thus, for Cantonese dominant children, the development rate of their Cantonese was higher than its development in their Putonghua dominant peer, and the rate of phonological development of Putonghua was observed to be higher in Putonghua dominant children than its development by the Cantonese dominant group. Typology of phoneme emergence was observed to be similar across both languages, in which plosive and nasal consonants emerged before fricative, lateral approximant and affricate consonants across both groups, supporting Jakobson's (1968) universal tendencies. Error pattern analysis revealed similar trajectories between monolinguals and their age-matched dominant bilinguals of the same language. The authors concluded that, although language dominance played a significant role in determining the profile of phonological acquisition, other factors such as the contrast between the phonological systems and complexity also affected phonological acquisition.

Alternatively, MacLeod and Fabiano-Smith's (2015) study demonstrated that language structure played a significant role in determining the rate of acquisition, while language exposure did not affect the acquisition rate of the allophonic rule in the bilingual acquisition. The author investigated the rate of acquisition of the allophonic rules by three-year-old Spanish-English and French-English bilinguals and their monolingual peers. They hypothesized that limited language exposure to each language compared to monolinguals would result in higher rates of error production of allophonic patterns. On the other hand, they predicted that language structure would have no impact on the bilingual acquisition rate of this subcomponent. The outcome of their study revealed that Spanish-English bilinguals produced higher error

rates than Spanish monolingual children, while French-English bilingual children produced lower error rates compared to their French peers.

In a related study, Mayr *et. al.* (2015) investigated the acquisition of word-final consonant clusters for 40 Welsh-English bilingual children aged between 2;6 and 5 years old. The participants were divided into two groups (20 each) according to their language dominance. Data revealed that age and dominance influenced acquisition in a substantial way, resulting in the advanced performance of the Welsh dominant group compared to the English dominant group in final cluster acquisition in Welsh. In addition, the Welsh dominant bilinguals did not exhibit any deceleration in their production of English final clusters compared to the other group. Both groups exhibited acceleration in their acquisition of final clusters in English compared to monolingual speakers. With language complexity, the results also indicated that, regardless of language dominance, bilinguals acquired the consonants of word-final clusters in English at a faster rate than in Welsh. This result demonstrated that the rate of acquisition of certain phonological components is determined by articulatory and perceptual difficulties, where Welsh word-final clusters are seen as more complex than the English ones. The results also revealed instances of cross-linguistic transfer in which the phoneme /l/ was vocalized by the English-dominant group in their production of the clear /l/ in Welsh. The authors concluded that the exposure of two languages could be a facilitative factor in bilingual's phonological acquisition.

Research on bilingual children's phonological acquisition often used a broad measure of PCC to report findings and compare bilingual acquisition to monolingual acquisition. Only a few studies have investigated the complexity of bilingual children's phonetic inventories in their languages or across aged-matched monolingual children. Fabiano-Smith and Goldstein (2010) compared the differences

and similarities between the acquisition patterns of monolingual and bilingual groups using a narrow measure of EML categories. They argued that PCC was used widely in previous studies, which failed to provide information on rates of development of certain sounds or classes of sounds. Cross-sectional design was adopted for children aged three to four years old and included eight bilingual children and their similarly age-matched monolinguals in Spanish and English. Their findings revealed that in English, monolinguals and bilinguals demonstrated no significant differences in their PCC scores. Conversely, Spanish monolinguals exhibited higher accuracy rates of PCC than bilinguals. This demonstrated that the bilingual children took different trajectories in acquiring each of their languages. For the EML accuracy measure, the analysis revealed that, for English production, the difference between monolingual and bilingual groups was found in the accuracy of early-developing sounds. As for EML in Spanish production, no significant differences were found in the accuracy across EML categories by the bilinguals, while Spanish monolinguals demonstrated simple to complex manners of acquisition in the accuracy of the early-, middle- and late-developing sounds. Moreover, bilinguals demonstrated different pattern of acquisition in EML across their languages. In English, they exhibited significant differences in the accuracy between early- and middle-, middle- and late- and early- and late-developing sounds. These differences demonstrated an easy to complex acquisition pattern, from unmarked sounds to more complex marked sounds. However, in Spanish, the only significant difference in accuracy was found between early- and middle-developing sounds, demonstrating that the bilingual acquisition in Spanish proceeded in an asymmetrical manner.

Author	Number/age	Data collection	Conclusions
Law & So (2006)	100 bilinguals aged (2;6 - 4;11) Cross-sectional 50 Cantonese dominant 50 Putonghua dominate	Picture naming, story telling Measures: 1. PCC 2. Phoneme emergence 3. Error pattern	Language dominance affected the PCC score in which PCC of Cantonese was higher in Cantonese dominant bilinguals and vice versa. Error patterns observed to be similar to the monolinguals of the bilingual's dominant language. Phoneme emergence was similar across languages and the rate of acquisition of Cantonese was higher across all bilingual groups in comparison to Putonghua's acquisition irrespective of dominance
Gildersleeve-Neumann *et al.* (2008)	33 children (3;1-3-10) 20 Domin bili/E 10 Mon/E 3 Balanced Spanish-English bili Longitudinal	2 points in time, 8-month gap Picture naming task Measures: 1. Phonetic inventoried 2. PCC 3. Error pattern	Children have similar inventories, positive longitudinal effect for all groups, significant difference in PCC accuracy and error pattern frequency between dominant English bilingual and their balanced bilingual counterpart. Demonstrating that higher frequency of error pattern is typical in bilingual acquisition
Grech & Dodd (2008)	93 Maltese-English 137 Maltese (2 - 6)	Picture naming Measures: 1. PCC 2. Error patterns 3. Consistency	Children exposed to Maltese and English at home observed to have advanced phonological competence in comparison to children exposed to only Maltese at home
Fabiano-Smith & Barlow (2010)	Cross-sectional 8 Spanish-English bilinguals (3- 4) 8 English 8 Spanish	Picture naming test. Measures: PCC Phonetic inventory	Phonetic inventories of bilingual children's complexity are at comparable levels to monolinguals. PCC of bilingual children is lower than that of monolinguals on certain classes but within the normal range

Fabiano-Smith and Goldstein (2010)	Cross-sectional 8 Spanish-English bilinguals (3- 4) 8 English 8 Spanish	Picture naming test Measure: EML PCC	Differences in PCC accuracy of Spanish monolinguals and bilinguals but not in English demonstrates differences in acquisition trajectory cross-linguistically. EML categories in Spanish shows no significant differences in accuracy by bilinguals but exhibits simple-to-complex trajectory by Spanish monolinguals. However, accuracy from early- to middle- to late- developing sound categories largely decreased in the bilingual production. EML categories in English show differences in accuracy by bilingual children exhibiting similar developmental patterns as monolinguals
MacLeod & Fabiano-Smith (2015)	Cross-sectional (3-4) 8 Spanish-English bili 8 Spanish mono 9 French-English bili 9 French mono	Single word sample for the Spanish study and spontaneous speech sample for French study Measure: allophonic rule	Differences between the two bilingual groups in comparison to their age matched bilinguals. Spanish bilinguals produced more errors than their age-matched Spanish monolinguals, while French bilinguals produced fewer errors than French monolinguals
Mayr *et. al.* (2015)	40 Welsh-English (2;6-5) 20 Dominant Welsh 20 Dominant English	Picture naming Measure: Word-final consonant clusters in Welsh and English	Age and dominance exhibited a direct influence in the acquisition of word-final clusters. However, Welsh dominant did not show any delay in that regards compared to the other group. The acquisition of English final cluster proved to be accelerated by the bilinguals compared to age-matched monolinguals. Transfer of English vocalized /l/ to the production of Welsh clear /l/ by English dominant group

Table 2-11: Summary of bilingual phonological acquisition research

2.3.2.2 Error patterns

Table 2-12 reports the findings of error pattern production by bilingual children aged from two to six years old in comparison to their age-matched monolinguals by different studies, reviewed in detail in the previous section. The results indicate divergent findings; some exhibit lower rates of error production by bilinguals (Grech & Dodd, 2008; MacLeod & Fabiano-Smith, 2014 for French bilinguals); other studies demonstrate higher rates of error pattern production by bilinguals (MacLeod & Fabiano-Smith, 2014 for Spanish bilinguals; Gildersleeve-Neumann *et al.*, 2008) than their monolingual counterparts. Scholars have attributed these discrepancies to different factors such as language dominance and/or the complexity of the target language structure.

Study	Sample	Criteria	Monolingual Norms
Law & So (2006)	(2;6-4;11) 50 Cantonese dominant/50 Putonghua dominate	Errors that are produced by more than 10% of the children in an age group	Similar error patterns in their dominant language
Gildersleeve-Neumann *et al.* (2008)	(3;1-3-10) 20 Domin bili/E 10 Mon/E 3 Balanced Spanish-English bili	Over of 5% occurrence in the error sample.	Significant difference in PCC accuracy and error pattern frequency between dominant English bilingual and their balanced bilingual counterpart, demonstrating that higher frequency of error patterns is typical in bilingual acquisition
Grech & Dodd (2008)	(2-6) 93 Maltese-English 137 Maltese	If present in the speech production of at least 10% of children in an age group	The analysis showed a decrease over age range of error patterns. The bilingual group and monolingual group shared many patterns up to age four. After four years old, the differences between the groups significantly increased, with fewer error patterns observed in the bilingual group
MacLeod & Fabiano-Smith (2015)	(3-4) 8 Spanish-English bili 8 Spanish mono 9 French-English bili 9 French mono	A ratio of absence of the target allophone in its obligatory context was obtained	Spanish bilinguals produced more errors than their age-matched Spanish monolinguals, while French bilinguals produced fewer errors than French monolinguals (allophonic rule)

Table 2-12: Summary of error pattern studies on pre-school bilingual children

Established developmental norms of bilingual phonological acquisition are still subject to wide controversy in the literature. These confounding findings are the result of many factors, such as methodological limitations, heterogeneity of the bilingual populations and an absence of an adequate research model. In addition, knowledge of the acquisition process of bilinguals requires an in-depth investigation. However, most of the recent studies reviewed used cross-sectional design. Earlier research has adopted case study design and present in-depth data (Vogel, 1975; Schnitzer & Krasinski, 1994), but its main theoretical concern was whether bilingual children start with a unitary phonological system or two and did not provide any knowledge regarding bilingual acquisition in comparison to monolingual acquisition rates or patterns. Therefore, this current study attempts to provide in-depth data for the acquisition process of three English/Arabic bilingual children in the light of recent theoretical views in this area. This inquiry will also contribute to the field of phonological acquisition of Arabic bilingual children where, as far as I am aware, no published study investigated the patterns of language development and interaction of this population longitudinally.

3.2.3 Research questions

Three research questions guided this investigation: (1) What are the phonological acquisition and development patterns for Arabic/English bilingual children in each language? (2) How does the phonological acquisition process of Arabic/English bilinguals differ from their monolingual peers in each language? (3) To what extent do the bilingual children's two phonological systems interact with each other during acquisition?

3 Methodology

3.1 Introduction

The dual interactional model of linguistic acquisition hypothesize that bilingual children have two separate but non-autonomous mental representations of their languages, as introduced in Chapter 1. Cross-linguistic interaction was viewed as a sign of that non-autonomously. Three hypotheses were formulated to account for cross-linguistic interaction by Paradis and Genesee (1996): transfer, acceleration, and deceleration. The analysis was conducted to address the theoretical question of cross-linguistic interactions by quantifying its manifestations in the bilingual phonological acquisition using the following measurements: PCC, phonemic repertoire and error patterns. Segmental phonology approach is selected for the current analysis that common in clinical type studies of both monolingual and bilingual phonological acquisition. This approach is adopted for its rigorousness and capacity to quantify qualitative data to answer the research questions.

3.2 Participants

The participants of this study were three bilingual children, two girls and one boy, aged two years old. Saudi parents doing postgraduate degrees in the UK, from the author's network, were contacted and asked to participate in the current study. Initial acceptance was received from several parents; only three children met the inclusion criteria and were recruited. Inclusion criteria included age of first exposure to English, age, and exposure to both languages. These criteria enabled the control of these factors to evaluate the extent of interaction.

All children are considered to be simultaneous bilinguals because they have been exposed to both Arabic and English before their second birthday. They were typically developing, with hearing within normal limits. Anonymity measures were followed to maintain privacy and confidentiality. Each participant was given a code for identification throughout the study. The linguistic history of two of the participants exhibits some similarities, while the third participant has a different linguistic profile. MF and SF were attending nursery full time and had comparable proficiency levels at the beginning of data collection period. On the other hand, the third participant, AM, was attending the nursery on a part-time basis at the beginning of data collection; toward the end of data collection, his circumstances changed when he and his family went back to Saudi Arabia for three months. These changes are reflected in his linguistic acquisition trajectory. In terms of the sample's socio-economic status, all their parents come from similar educated, middle-class backgrounds. Recruitment and data collection took place in three areas in the United Kingdom: Aberdeen, Glasgow and Reading, Berkshire.

3.2.1 MF

MF arrived in the United Kingdom as an eleven-month-old when her mother was accepted to a Ph.D. program in Reading, Berkshire. MF has one sister who is four years older than she is. Both were born in Kuwait. The participant’s mother comes from Saudi Arabia, while her father is from Kuwait. Prior to arrival in the United Kingdom, the participant was exposed to Arabic exclusively, even though both of her parents are fluent speakers of English.

Upon their arrival in the United Kingdom, she was enrolled in an English-speaking nursery on a full-time basis. While the primary language spoken at home by the parents is Arabic, her mother sometimes code-switched between Arabic and English when addressing MF because she feels that her Arabic comprehension is very limited. Moreover, they travel back to Kuwait for a month once every year during the summer time.

As far as Arabic is concerned, MF's comprehension is higher than her production, according to her mother's report. Subsequently, she seems to be shy when communicating in Arabic in the presence of strangers. She speaks only in Arabic with her mother and father. She communicates with her sister in English most of the time. Her mother reads to her in Arabic at home and she watches some Arabic programs on television. She is described as having a native-like Berkshire British accent by English native speakers, and as the study progressed, her exposure of English became higher than Arabic. Her English proficiency is comparable to English monolinguals, whereas her Arabic is reported to be within functional parameters. For more information, refer to Table 3-1.

3.2.2 SF

SF arrived in the United Kingdom from Saudi Arabia at seventeen months old when her mother was accepted to a Ph.D. program at Aberdeen University in Scotland. SF is the youngest of three children. She has two older brothers, who are four and six years older than she is. When her parents arrived, she started attending an English-speaking nursery full time. Her mother described her daughter's language

proficiency as being good in both languages at the beginning of data collection. The mother also observed that her daughter has a slight foreign accent in both Arabic and English. In terms of code-switching, the mother reported that her child mixes both languages slightly, with Arabic being the dominant language. She emphasized that the dominant language spoken at home is Arabic. The mother seems very keen on encouraging her children to speak Arabic at home all the time.

Moreover, the family has many Arabic acquaintances that had an impact on the amount of Arabic language input the participant was exposed to. Her mother reported that 90% of SF's communication during the day is in English, as she attends the nursery full time. However, she speaks mainly in Arabic, estimating to 90% when she communicates with her parents and siblings. In addition, she watches 50/50 Arabic and English programs. She uses both Arabic and English when expressing her emotions. For more details, refer to Table 3-1.

3.2.3 AM

While the families of MF and SF moved to the United Kingdom after their birth, AM's parents arrived in the United Kingdom shortly before his birth. Before his father started his Ph.D. in Glasgow, he was studying English in Newcastle, which was the birthplace of AM. When AM was ten months old, they moved to Glasgow and lived there until the end of the data collection period. The participant is the youngest and has two older siblings: a brother who is seven years older and a sister who is three years older.

At the beginning of data collection, his mother was attending an English language course to prepare for her graduate degree in education. At home, while his mother's communication was mainly in Arabic, his siblings interacted with him in both English and Arabic. In terms of his linguistic profile, AM started attending an English-speaking nursery on a part-time basis (20 hours per week) when he was 25 months old. On non-nursery days, his screens consist of four-hour English shows. However, his linguistic acquisition trajectory took a new turn once his parents went to Saudi Arabia for three months; at that time, Arabic language proficiency exceeded his English. The family had arrived in the United Kingdom when he turned 2;10 years old and was not enrolled in a nursery thereafter.

3.2.4 Summary of participants' linguistic profiles across languages

Table 3-1 illustrates linguistic profiles for all the participants presenting: age, gender, and language input and proficiency cross-linguistically. This data was obtained from the language history questionnaire supplied by their mothers at the beginning of data collection (Appendix 1), which was adapted from Li *et al.* (2006). Any changes in the children linguistic environment were reported in the analysis chapters.

Participant	MF	SF	AM
Gender	F	F	M
English exposure:			
1. Nursery	Full-time	Full-time	Part-time/ 2 days
2. At home			
Interaction with parents	70%	10%	10%
Interaction with sibling(s)	90%	10%	20%
Language use	80-70%	0%	15%
T.V.	70%	50%	90%

3. Proficiency			
Speaking	Native-like (7/7)	Good (5/7)	Functional (4/7)
Listening	Native-like (7/7)	Native-like (7/7)	Good (5/7)
4. Accent	No	Yes (2/7)	Yes (4/7)
Arabic exposure:			
1. At home			
Interaction with parents	30%	90%	90%
Interaction with sibling(s)	10%	90%	80%
Language use	20%	100%	85%
T.V.	30%	50%	10%
2. Proficiency			
Speaking	Functional (4/7)	Good (5/7)	Native-like (7/7)
Listening	Good (5/7)	Native-like (7/7)	Native-like (7/7)
3. Accent	Yes (4/7)	Yes (2/7)	No

Table 3-1: Summary of participants' linguistic profiles

3.3 Data collection

3.3.1 Ethical approval

The process of collecting data from vulnerable populations like children needs to take into account several considerations. Ethical approval was obtained prior to the commencement of the study. The Proposal Form for Ethical Review and supporting documentation had been submitted to the Departmental Research Ethics Officer. The School Ethics Committee had accepted the proposal after it was reviewed. After acceptance was granted, the children's parents were sent a consent form that explained the nature of the research and explaining the anonymity and confidentiality of data.

3.3.2 Procedure

Data were collected in a semi-structured manner inclusive of both spontaneous speech and word-list. The children’s speech was recorded at approximately four-week

intervals over a one-year period. The mothers were asked to record their child for approximately one hour each month while interacting with them. Multiple sessions were recorded each month, contingent upon the child's cooperation, in an attempt to collect as much data as possible. Some of the sessions were collected on different days (but at the end of each calendar month) pertaining to the mothers' schedule or the children's cooperation. The data collection took place in the children's home. The familiar and naturalistic settings helped in stimulating the data. Separation of the two languages in the recording sessions was not always achieved, especially in the first six months of data collection due to the children's limited lexicon. Both imitated and spontaneous production was included to cover any lack of proficiency in their language(s).

Activities comprised conversations, free-play, singing and storytelling. In addition, the mothers were provided with two lists that account for the phonemic inventories for each language in three different word positions; I, M and F. These were provided in two forms, printed pictures and as powerpoint slides, depending on the mother's preference. The English list was adapted from Dodd *et. al.* (2002) (see Table 3-2). The Arabic word list was a modified version of Ayyad's (2011) (see Table 3-3.) Additional ad hoc word lists were prepared on a monthly basis, customized for each of the children, to further evaluate particular sounds.

English word list

	WI	WM/ end of the syllable	WF
b	bɹɪdʒ (bridge), bɔɪ (boy)	ʌmˈbɹɛlə (umbrella)	wɛb (web)
p	pɪg (pig)	ˈæpl (apple)	ʃiːp (sheep)
t	ˈtaɪgə (tiger)	təˈmɑːtəʊ (tomato)	ˈɛlɪfənt (elephant)
d	dʌk (duck)	ˈspaɪdə (spider)	ɹɛd (red)

k	kræb (crab), ˈkɪʧɪn (kitchen), kwiːn (queen)	mʌŋki (monkey)	sneɪk (snake), bʊk (book)
g	glʌvz (gloves)	ˈtaɪgə (tiger)	ɛg (egg)
m	ˈmʌŋki (monkey), ˈmʌðə (mother)		pɹæm (pram)
n	naɪf (knife)		væn (van), tɹeɪn (train)
ŋ		ˈfiŋgə (finger)	swɪŋ (swing)
f	fɹɒg (frog), ˈflaʊə (flower), flaɪ (fly)		ʤɪˈɹɑːf (giraffe)
v	væn (van)		faɪv (five)
θ	θɹiː (three)	ˈtuːθbrʌʃ (toothbrush)	tiːθ (teeth)
ð	ðɪs (this)	ˈfɛðəɹ (feather), ˈfɑːðə (father)	
s	skweə (square)	ˈsɒsɪʤ (sausage)	ˈbɪskɪts (biscuits)
z	ˈziːbɹə (zebra)	ˈsɪzəz (scissors)	glʌvz (gloves)
ʃ	ʃiːp (sheep)	ˈfɪʃɪŋ (fishing)	ˈtuːθbɹʌʃ (toothbrush), splæʃ (splash)
tʃ	ˈʧɪkɪn (chicken)	ˈpɪkʧə (picture)	wɒʧ (watch)
dʒ	ʤʌmp (jump)		bɹɪʤ (bridge), ˈɒɹɪnʤ (orange)
h	ˈhɛlɪkɒptə (helicopter)	ˈlaɪthaʊs (lighthouse)	
ɹ	ˈɹæbɪt (rabbit)	ʤɪˈɹɑːf (giraffe), ˈstɹɔːbəɹi (strawberry)	
l	ˈlaɪthaʊs (lighthouse)	ʌmˈbɹɛlə (umbrella)	ˈæpl (apple), skuːl (school)
w	wɒʧ (watch)		
j	ˈjɛləʊ (yellow)		

Table 3-2: English word list

Arabic word list

	WI	WM/ end of syllable	WF
b	bɪnt (girl)	sˁaˈbuːnə (soap bar)	kɛlb (dog)
d	ˈdəwa (medicine)		ˈwələd (boy)
t	taħat (downstairs)	mɪfˈtaħ	bɪnt (girl)
tˁ	ˈtˁaːulə (table)	ˈbʌtˁːə (duck)	χeːtˁ (thread)

k	kɛlb (dog)	ˈsejkəl (bicycle)	ˈsəmək (fish pl)
g	gɪdər (pot)	mɪlˈʕəgə (spoon)	foːg (upstairs)
q	qeˈtˤaːr (train)	ˌbʊrtuˈqalə (orange)	
ʔ	ʔəˈsnaːn (teeth)		laʔ (no)
m	mɪfˈtaħ (key)	ˈsəmək (fish pl)	ˈχaʃəm (nose)
n		ˈʔərnəb (rabbit)	ʔaˈsnaːn (teeth)
f	foːg (upstairs)	tʊˈfaħə (apple)	χaˈruːf (sheep)
s	sɛriːr (bed)	ˈkirsi (chair)	fluːs (money)
sˤ	ˈsˤaħan (plate)	ˈwʌsˤəχ(dirty)	maˈsˤːəsˤ (lollipop)
θ	θəˈlæːθə (three)	θəˈlæːθə (three)	muˈθəlːəθ (triangle)
ð		ˈhaðə (this)	ləðiːð (delicious)
ðˤ	ðˤəlaːm (dark)		
z	ˈzəʕtər (Oregano)	ˈmoːzə (banana)	
ʃ	ˈʃəntˤə (bag)	ˈmɪʃətˤ (comb)	
χ	χeːtˤ (thread)		ˈwʌsˤəχ (dirty)
ʁ	ʁəˈsaːlə (washing machine)	məʁˈsələ (skink)	
ʕ	ˈʕi(j)nəb (grapes)	ˈʃaʕar (hair)	ʔˈsˤbəʕ (finger)
ħ	ħeˈdʒaːb (hairscarf)	taħat (downstairs)	mɪfˈtaħ (key)
h	ˈhəwə (air)		ˈsəməkəʰ (fish)
dʒ	dʒəmal (camel)	ħeˈdʒaːb (hairscarf)	
r	rɪdʒɛl (foot)	ˈkɔrə (ball)	sɛriːr (bed)
l	lejl (night)	ˈwələd (boy)	fiːl (elephant)
lˤ			
j	jaːkəl (eating)	tˤəˈjːaːrə (airplane)	
w	ˈwʌsˤəχ(dirty)	ˈdəwa (medicine)	

Table 3-3: Arabic word list

3.3.3 Recording method and transcription

The participants' speech was audio-recorded by their mothers using their smartphones. The data was sent by email at the end of each month. Each recording has been transcribed using the IPA phonetic inventory. The Audacity program was used, which facilitated the repetition of a particular segment of the audio recording when needed to ensure the accuracy of the transcription.

3.3.3.1 Definition of acceptable responses

Dialectal variation was taken into consideration when conducting the phonological analysis. Any substitution of phones that mark the local accent for the parents or the places where the children lived in was considered acceptable. Below is a summary of some of the dialectal variations that were being considered in the analysis. Moreover, some of the data was excluded when there was a loud background noise and the quality of the recording was not up to the standard level.

Accent	Berkshire	Scottish English
Rhoticity	No	Semi-rhotic
/r/	Approximant [ɹ]	Two varieties; [ɹ] and [ɾ]
/θ/	[f]	[θ]
/l/	Two allophonic variations; clear [l] and dark [ɬ]	Mostly realized as [ɬ] in all positions
/ŋ/	[ŋ]	[ŋ]

Table 3-4: Dialectal variations (Cruttenden, 2014; OED, 2018)

2.3.3.2 Reliability of transcription

To check the reliability of transcription, 10% of all the data was analysed for inter-rater reliability by a linguist proficient in Arabic and English language. For the Arabic data, inter-judge reliability reached 96.77% for broad transcription. For the English data, inter-judge reliability reached 98.61% accuracy for broad transcription.

3.3.4 Analysis

Data transcription was conducted during the period of data collection. Monthly analysis of each child's transcript was fundamental in establishing their: (1) PCC; (2) phonemic inventory; and (3) error patterns. This step helped in composing an additional ad hoc word list to further assess each child's phonological acquisition and development. Excel sheets were used as a medium for documentation and quantifying errors for each language. This method shed light on the context of the errors and quantified different tokens of lexical items. After that, the transcriptions were checked again for reliability, which took an additional three months after the end of data collection. Moreover, the phonological analyses were only conducted on the children's intelligible words; when a word seemed unintelligible or unclear, it was discarded from the transcription.

The items included in the analyses constituted isolated single words and words from utterances. In the analysis, it has been noted whether a word was produced in isolation or as part of an utterance in order to distinguish between the two contexts if needed. The following measures were implemented.

3.3.4.1 Segmental acquisition

The first set of analysis was directed toward establishing the participants' segmental acquisition for English and Arabic consonants for a one-year period. Analysis of segments was based on their occurrences in different lexical items and tokens in at least two-word positions. Three criteria were selected to establish the level of acquisition: mastery, acquisition and customary. These criteria were derived from previous cross-sectional studies (Amayreh & Dyson, 1998). It is important to emphasize that these criteria were used to establish the segment acquisition accuracy for a group of children; in this context, they were used to calculate the accuracy of production for each participant individually. A phoneme was considered mastered if its accuracy of production score was between 100- 90%; for acquisition level, the accuracy of production was expected to be within 89-75% range and customary production criteria was between 74-50% range of all target attempts. The percentages were based on the following formula:

$$\left(\frac{no.segment\ /x/\ correct\ production}{total\ no.of\ attempted\ [x]\ production}\right) \times 100 = \text{segment accuracy of production percentage}$$

The deletion of a particular phoneme was not considered as a failed attempt of production and was not accounted for in the segmental acquisition. Nevertheless, it was reported in the analysis of error patens.

1. Segment acquisition and substitution

A phoneme is included in the participant inventory if it was mastered. Mastery is based on at least 90% accuracy of production in the speech sample of the participant, which was calculated for each sound monthly.

A substitution pattern of each sound is also discussed in the analysis of error patterns in the error analysis section. However, in the error analysis section, it was addressed more generally. In the phonemic acquisition context, all possible substitutions were established for each individual sound along with their reoccurrences longitudinally and cross-linguistically. This is crucial to establish possible patterns of production to identify any signs of cross-linguistic interaction between the bilingual languages.

2. PCC

The difference between segmental acquisition and PCC is that the PCC calculation is based on the total correct segment production of the participants' speech sample. This measure was utilized to discern any longitudinal effects and create additional measures of comparison across participants and studies.

3.3.4.2 Error analysis

The second set of analysis was directed towards the children's errors. The errors were analysed qualitatively and quantitively. For qualitative analysis, the following criterion was established to determine the existence of an error pattern: An error pattern is considered to be present if it had more than five occurrences in different lexical items, which is to allow comparison with Dodd *et. al.* (2006) for the English data. Allophonic variation is not considered to be error and is judged depending on the local dialect and communities where the children reside in and come from. As for the quantitative analysis, the following measures were used: type and frequency. Definitions of error patterns are provided in Appendix 2.

1. Type analysis

Under the type analysis, all errors during the data collection period were analysed based on their occurrence in different lexical items and tokens and categorized into three sets of errors types: substitution, assimilation, and syllable error patterns. For each category, error patterns were identified and divided by the total number of errors in that respective category to drive a percentage of occurrences of that error within each category. For example, if stopping errors occurred 56 times in different lexical items and tokens during the whole data collection period, we divided it by the total number of substitution error occurrences. Discussion of each type of error was conducted at two stages. First, each error pattern was analysed within its category type. Quantitative data was derived by calculating the number of occurrences of each error type by the number of occurrences of errors in that category. Second, the number of occurrences of each error pattern throughout the data collection period was divided by the number of total occurrences of all the errors. The aim of this step was to provide a base for longitudinal comparison across all error patterns. Additionally, cross-linguistic comparison measures were used to compare error patterns across languages. This measure was established by dividing occurrences of each error pattern by the total occurrences of all errors across the two languages.

2. Frequency analysis

Frequency measures were established to present a longitudinal comparison frame. The occurrences of each error were calculated based on the number of occurrences in different lexical items and tokens on a monthly basis. Errors that

occurred in less than five different lexical items or tokens during the whole period of data collection were not considered in the analysis for both frequency and type measures. Moreover, across language comparison was based on the number of occurrences of an error each month in different lexical items and tokens.

3.4 Summary

To summaries, Three 2;5-year-old participants were recruited to take part in this study from different parts in the UK: Reading, Aberdeen, and Glasgow. Simultaneous and elicited speech data were recorded on a monthly basis by their mothers for a one-year period. All participants are considered to be acquiring Arabic and English simultaneously. Language history questionnaire is administered to account for their language exposure patterns and their linguistic behaviors. Paradis & Genesee (1996) model is adopted to evaluate the extent of cross-linguistic interaction against three measurements of phonological acquisition and development; PCC, phonemic repertoire and error patterns. Manifestations of interaction are hypothesized to take three forms; transfer, acceleration, and delay. While the transfer is judged independently, the other two hypotheses in that model require comparison to monolingual norms in each language. These norms were derived from cross-sectional studies reviewed in the previous chapter.

4 Case study (MF)

4.1 Results

This section is a detailed account of MF's phonological acquisition throughout the data collection period. The results are divided into three different sections: (1) English data, (2) Arabic data and (3) a comparison between English and Arabic phonological development.

4.1.1 English data

Three measures were used to evaluate the speech production of the participant: PCC, phonemic repertoire and error analysis.

4.1.1.1 Percentage Consonant Correct (PCC)

The participant's PCC was calculated at two different points: when the participant was 2;6 and at the last month of the data collection period, when she reached 3;5 years old. The average percentage was computed by adding the PCC percentages of the first month and last month of data collection and divided by two. The results are presented below:

PCC	English
2;6	84%
3;5	92.8%
Average	88%

Table 4-1: English PCC

On average, the participant had a score of 88%. At the beginning of data collection, MF's percentage was reported to be 84%, while at the end of data collection period an 8.7% rise was observed.

4.1.1.2 Phonemic repertoire

Data was collected when the subject was two-and-a-half years old; at that age, it appears that most of her English inventory was completed. However, there seem to be a regression in the production of two sounds: /v/ and /θ/ at the age of 2;9 and at 3 years old. After that, these phonemes had stabilized. I will be presenting the data of the participant's segmental production according to the sound articulation manner. In each section an account of the production accuracy is reported as well as any substitutions.

1. Plosives

Table 4-2 reveals the acquisition pattern of plosive consonants by the participant. It appears that her plosives were acquired and stabilized early in the beginning of data collection. Moreover, all her plosives were mastered when the participant reached 2;11 years old.

Age	P	sub	b	sub	t	sub	d	sub	k	sub	g	sub
2;6	100		89	[ɹ],[n]	96	[t̪]	94	[k]	90	[p], [kʰ]	84	[b]
2;7	100		100		100		100		94	[g]	83	[k]
2;8	100		89	[p]	94	[s]	100		100		100	
2;9	100		92	[mb]	93	[ʃ]	100		87	[p], [t]	100	
2;10	100		83	[ɹ]	100		100		100		100	
2;11	100		100		100		100		93	[g]	91	[d]
3	86	[k]	100		100		100		100		100	
3;1	92	[k]	100		100		100		100		100	
3;2	100		100		100		100		100		100	

3;3	100		100		100		100		100		100	
3;4	100		100		100		100		100		100	
3;5	100		100		100		100		100		100	

Table 4-2: English plosive consonants acquisition and substitution patterns

2. Fricatives

Table 4-3 demonstrates the acquisition pattern of fricative consonants by MF. At the end of data collection, all the fricatives were acquired, except for the interdentals. In terms of her accuracy of production, two sounds /f/ and /ʃ/ were acquired and stabilized early. In addition, the production of other fricatives was undergoing the error pattern of stopping; these phonemes were /v/ and /ð/. Phoneme /v/ was often realized either as the plosives [p] or [b]; at age 3;3 she had acquired it, but a regression was reported the next month. At the end of data collection, she reportedly had reached the acquisition score of 85%. On the other hand, /ð/ was substituted by the sound /d/ most of the time. This substitution could be attributed to an accentual feature of Berkshire English. On the other hand, the production of the phoneme /θ/ was inconstant and fluctuated throughout the data collection period. Two phonemes /s/ and /z/ had similar acquisition development patterns; however, the phoneme /s/ was mastered at the end of data collection. Interestingly, both were substituted by [ʃ]. In addition, /s/ was also realized as [θ] and /z/ as [ð].

Age	f	sub	v	sub	θ	sub	ð	sub	s	sub	z	sub	ʃ
2;6	100		50	[p]	33	[k],[t],[f]	44	[d]	83	[ʃ],[ts],[θ]	71	[ʃ],[s]	100
2;7	92	[p]	50	[b]	0	[k]	29	[d]	87	[ʃ], [θ]	90	[ʃ]	100
2;8	100		50	[ʌ]?	33	[ts],[s]	40	[d]	86	[ʃ], [θ]	67	[ð],[ʃ]	100
2;9	100		0	[b]	100		26	[d],[ʒ]	76	[ʃ], [θ]	71	[ð]	100
2;10	100		n/d		n/d		0	[d]	100		100		100
2;11	100		86	[b]	29	[p],[k],[f],[ʃ]	43	[d]	70	[ʃ], [θ]	67	[ð]	100
3	100		0	[p],[b]	0	[f],[t]	40	[d],[z]	81	[ʃ], [θ]	71	[ð]	n/d
3;1	100		41	[b]	25	[ʃ],[k],[s]	54	[d],[z]	100		75	[ð]	100
3;2	100		50	[p],[b]	67	[k]	25	[d]	100		80	[ð]	100
3;3	100		86	[p]	83	[s]	83	[d]	72	[ʃ],[z]	80	[ð]	100
3;4	100		33	[p],[b]	67	[f],[k]	50	[d]	100		50	[ð]	100

3;5	100		85	[p]	33	[fθ],[k],[s]	60	[d]	96	[ʃ]	82	[ð]	n/d

Table 4-3: English fricative consonants acquisition and substitution patterns

3. Nasal and approximant consonants

MF nasals and approximants were already acquired at the beginning of the data collection, as revealed by Table 4-4. She demonstrated high accuracy levels of production throughout this period for the these sounds, where all her nasals and approximants were mastered by the age of 2;11, except for /ɹ/. It is worthy to note that the substitutions of the phoneme /ɹ/ were a result of assimilation and metathesis phonological processes. For example, [ʌmˈblɛlə] for 'umbrella' and [jæɹɪt] for 'rabbit. ' Moreover, the substitution of the sound /j/ by [l] is the result of an assimilation process as well and occurred in only one word, where 'yellow' was realized as [lɛləʊ]. Nevertheless, it had stabilized at the age of 3;2.

Age	m	sub	n	sub	ŋ	sub	ɹ	sub	l	sub	j	sub
2;6	100		95	[m]	92	[ŋg]	87	[ʒ]	96	[ɹ]	91	[l]
2;7	89	[b]	100		100		100		100		90	[l]
2;8	90	[b]	100		100		87	[ɒ], [l]	100		90	[l]
2;9	90	[b]	87	[m]	100		100		100		90	[l]
2;10	100		100		100		100		100		90	[l]
2;11	93	[n]	94	[m]	100		100		100		90	[l]
3	100		91	[m]	100		100		100		90	[l]
3;1	100		94		100		85	[j], [dʒ]	100		90	[l]
3;2	100		100		100		100		100		100	
3;3	100		82	[m]	100		100		100		100	
3;4	100		100		100		100		100		100	
3;5	93	[b]	100		100		100		100		100	

Table 4-4: English nasal and approximant consonant acquisition and substitution patterns

4. Affricates

When it comes to affricates acquisition, it is apparent that they were acquired and stabilized early (see Table 4-5). Even with few reversal periods, they were mastered at an early stage.

Age	tʃ	sub	dʒ	sub
2;6	100		73	[tʃ], [ʃ]
2;7	100		100	
2;8	100		100	
2;9	100		100	
2;10	100		100	
2;11	92	[θ]	71	[d]
3	100		100	
3;1	100		100	
3;2	100		100	
3;3	75	[t]	100	
3;4	100		100	
3;5	100		100	

Table 4-5: English affricate consonants acquisition and substitution patterns

4.1.1.3 Error analysis

Two types of error pattern analysis were selected to establish the overall percentage of error occurrences and to provide longitudinal data of error frequency over time. The first set of analysis is type analysis while the other is frequency analysis.

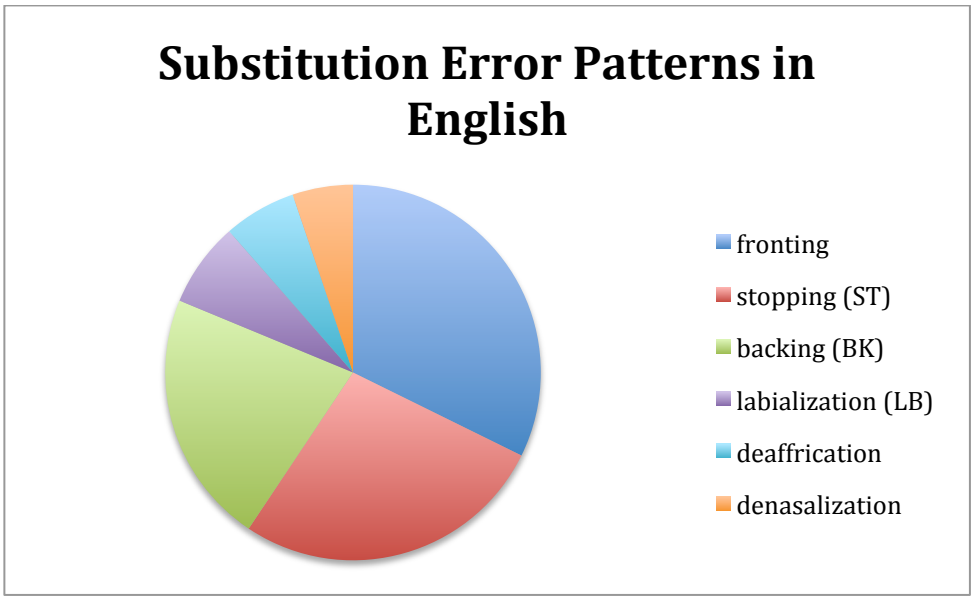
1. Type analysis

Errors were calculated based on their occurrence in different lexical items over the whole period of data collection. Any error that appeared in less than five lexical items was excluded. Then, the frequency of errors were compared and presented in the graphs. Moreover, these error patterns were categorized into three different groups: substitution, assimilation and syllable structure.

1.1 Subsitution error patterns

Graph 4-1 displays the most frequent substitution error patterns in the participant's production of English. Fronting, stopping and backing accounted for 32%, 27% and 22% of total substitution error patterns respectively, while labialization,

deaffrication and denasalization occurred in lesser frequency, scoring 7%, 6%, and 5% respectively.



Graph 4-1: Substitution error patterns in English

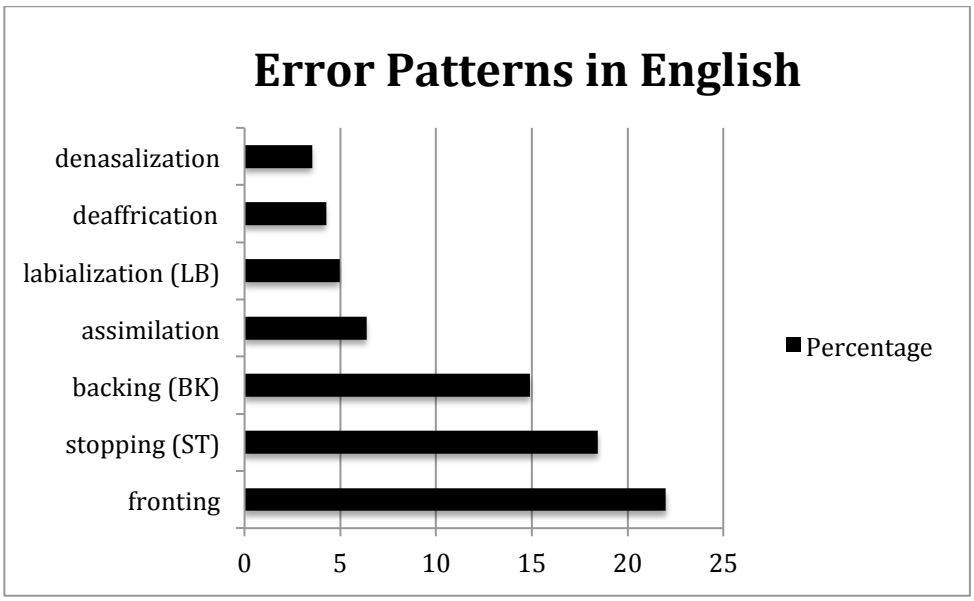
1.2 Assimilation errors

Assimilation error patterns account for 53% of total assimilation errors. Other assimilation errors appeared in less than five lexical items and were excluded from the analysis. In addition, syllable structure errors had rare occurrence of less than five items per error type and therefore did not meet the criteria.

1.3 Overall comparison in English

Graph 4-2 illustrates overall error patterns in English. Substitution error patterns were the highest occurring error type. Fronting error pattern was the most frequently occurring error pattern in the English data, followed by stopping and then backing, accounting for 22%, 18% and 15% of total error patterns respectively.

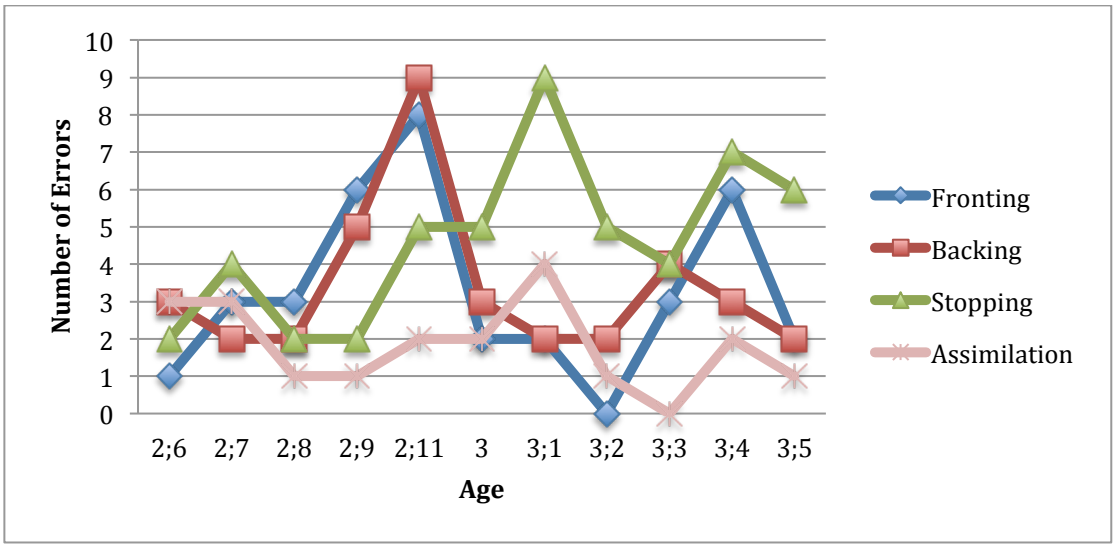
Assimilation error frequency reached 6%, while labialization, deaffrication and denasalization were reported in less than 5% of total English error patterns.



Graph 4-2: Overall error patterns in English

2. Frequency analysis

Graph 4-3 demonstrates the frequency of error pattern occurrences over the period of data collection. There seem to be a fluctuation of error occurrence rates that were not affected by age. Stopping and fronting error patterns displayed increased rates of occurrence over time, while the frequency of backing and assimilation error patterns dropped at the end of data collection after a noticeable peak.



Graph 4-3: Longitudinal frequency analysis of error patterns in English

4.1.2 Arabic data

4.1.2.1 Percentage consonant correct (PCC)

Table 4-6 illustrates the results of the participant's Arabic PCC. There was a 10.5% improvement of MF's production accuracy during one year.

PCC	Arabic
2;6	55.5%
3;5	66%
Average	60%

Table 4-6: Arabic PCC

4.1.2.2 Phonemic repertoire

1. Plosive

Table 4-7 exhibits MF's acquisition pattern of her Arabic plosives. It appears that her plosives were acquired early, since the beginning of data collection, except for /q/. The sound /q/ was realized as [g] for 98% of its average production during that year. Most of these phonemes were mastered and stabilized at the end of data

collection, except for /q/. No significant substitution patterns could be identified. However, the participant used the glottal stop [ʔ] to substitute /b/, /t/ and /q/, which will be further discussed in the error pattern section.

Age	b	sub	t	sub	d	sub	k	g	sub	q	sub
2;6	100		94	[d]	94	[t]	100	100		0	[g]
2;7	100		100		93	[g]	100	80	[w]	0	[g]
2;8	90	[ʔ]	100		100		100	100		0	[g]
2;9	79	[k],[p],[w]	100		100		100	100		0	[g]
2;10	n/d		100		100		n/d	n/d		0	[g]
2;11	83	[ʔ],[d],[g]	100		100		100	100		0	[g],[b]
3	100		100		80	[ð]	100	100		0	[g]
3;1	91	[ʔ]	100		100		100	100		0	[g]
3;2	100		87	[ʔ]	100		100	75	[k]	0	[g]
3;3	78	[ʔ],[t]	100		100		100	100		0	[g], [ʔ]
3;4	100		100		85	[dʒ]	100	100		0	[g]
3;5	100		100		94	[g]	100	100		25	[g], [ʔ]

Table 4-7: Arabic plosive consonant acquisition and substitution patterns

2. Fricatives

Table 4-8 displays the participant's production and substation patterns of Arabic fricatives over the one-year period. Her production of fricatives demonstrates great variability across age and place of articulation. The analysis and discussion of the fricative acquisition will be subdivided according to their place of articulation.

Age	f	sub	θ	sub	ð	sub	s	sub	z	sub	ʃ	sub	χ	sub	ʁ	sub
2;6	100		67	[s]	0	[d]	92	[ʃ]	60	[s] [dʒ] [ʒ][ʃ]	90	[ts] [s]	33	[h]	n/d	
2;7	92	[z]	n/d		100	(1)	53	[θ][b]	75	[s]	75	[s]	25	[h]	0	[h][g]
2;8	100		n/d		n/d		57	[θ][t]	20	[ʒ][s] [ð]	80	[tʃ]	56	[h] [ʃ]	0	[g] l
2;9	83	[v]	100		n/d		67	[θ]	n/d		100		67	[h]	n/d	
2;10	100		100	(1)	n/d		100		n/d		100		n/d		n/d	
2;11	91	[r]	100	(1)	100	(1)	79	[ð][θ]	25	[ð]	100		33	[h]	0	[ʔ][χ] [h][g]
3	100		100		n/d		75	[θ]	33	[ð]	n/d		25	[h]	n/d	
3;1	93	[h]	80	[ʔ]	n/d		90	[θ]	50	[ð]	100		40	[h] [b]	0	[θ] l
3;2	100		86	[ʔ]	n/d		100		67	[ð]	86	[tʃ]	57	[h]	n/d	
3;3	89	[b]	57	[ʔ][s] [l]	0	[d] (1)	100		17	[ð]	70	[s]	54	[h][k] [ħ]	n/d	
3;4	100		100	(2)	100	(1)	80	[θ]	0	[ð]	86	[s]	67	[h]	0	[g][ʔ][χ]
3;5	100		83	[f]	100	(2)	40	[d]	45	[ð]	83	[s] [t]	83	[h]	ʁ(1)	

Table 4-8: Arabic fricative consonant acquisition and substitution patterns

2.1 Labiodental and interdentals

Table 4-8 shows that the phoneme /ð/ was introduced at age 2;7 with a single occurrence. At 2;8, 2;10, 2;11, 3, 3;1, no word containing that sound was produced. At 3;2 and 3;5, it appeared in alternation with the phoneme [d] and was not stabilized through age 3;5, although /ð/ appeared to predominate at 2;9 and 3;1. It is worthwhile to note that there was not enough data to paint a complete picture of its acquisition throughout data collection. Nevertheless, at the end of data collection it was produced correctly in two different lexical items. On the other hand, its voiceless counterpart /θ/ demonstrated different developmental pattern. Its production alternated with the glottal stop [ʔ] over some months. Its accuracy had reached 100% when the participant was 2;9, 3 and 3;4. However, it did not stabilize at the end of data collection. On the other hand, the labiodental /f/ was acquired at the beginning of data collection and mastered and stabilized by 3;4.

2.2 Alveolar and post alveolar consonants

Both phone-segments /s/ and /z/ had development patterns that demonstrated fluctuation over the period of data collection, while /ʃ/ had been acquired early but was not stabilized at the end of data collection, as demonstrated by Table 4-7. The phoneme /s/ seemed to have a higher accuracy overall score. At 2;10, 3;2 and 3;3, the phoneme /s/ reached mastery level. However, it dropped to 40% at the end of data collection and was often realized as [θ] throughout the year of data collection. As for the phoneme /z/'s acquisition pattern, on average the participant scored below 50% in terms of accuracy and reached acquisition level at 2;7 years old. At the end of the data

collection period, its accuracy dropped to 45% and was constantly being substituted by [ð], with no sign of stabilization.

2.3 Pharyngeal consonants

The phoneme /χ/'s acquisition pattern could be described as developmental with few fluctuations. Her accuracy of production had advanced 50% from the beginning of data collection, where she scored 33%, and reached acquisition level at the last month of data collection and was often realized as the sound [h]. In addition, Table 4-7 indicates that the phoneme /ʁ/ only reached its target value once at the end of data collection. There is not enough data to demonstrate whether it stabilized or not at that age. Throughout the year, its production showed substitution of the target value by the different sounds [h], [g] and [ʔ].

Phoneme /ʕ/'s acquisition pattern could be described as developmental; at 2;6, its production showed extreme variation, alternating between two sounds [ʔ] and [ə] most of the time. However, between 2;11 and 3, it was realized exclusively as phone-segment [ʕ] and it had never stabilized. The phoneme /ħ/, on the other hand, had a higher occurrence rate than [ʕ] but with greater inconsistency. For that segment, the participant reached customary levels at the beginning of data collection. After that, its attainment level fluctuated and reached the customary production at three years old and was de-pharyngealized into [h] most of the time, with no sign of stabilization.

2.4 Emphatic consonants

Phoneme /sˤ/ was realized as [s] constantly and appeared once with its target value in the middle position, with 10% at the beginning of data collection, after which it was not pronounced as [sˤ] again until 3;1. Furthermore, its target production reappeared on 3;3 and 3;5 with single occurrences. Similar acquisition patterns were shared with the emphatics /tˤ/ and /dˤ/, in which they often were de-emphasized into their plosive counter parts as illustrated by Table 4-8.

There was not enough data to account for the occurrences of the emphatics /ðˤ/and /lˤ/, as the participant seemed to avoid words containing these segments due to their complexity of production.

Age	ħ	sub	ʕ	sub	tˤ	Sub	sˤ	sub	ðˤ	sub	dˤ	sub	lˤ	sub
2;6	71	[h],[k]	0	[ʔ],[b],[h],[e],[ə]	0	[d] [t]	10	[s],[f]	0	[d],[v]	0		n/d	
2;7	50	[h]	ʕ(1)	[ʔ]1	0	[d] [t]	0	[s],[ʃ]	ðˤ(1)		0		n/d	
2;8	66	[h],[θ]	0	[ʔ]	0	[d]	n/d		n/d		n/d		n/d	
2;9	33	[h]	0	[ʔ],[w]		[d]1	0	[s]2	n/d			[d]1	n/d	
2;10	n/d	n/d	n/d		0	[d],[t]	0		n/d		n/d		n/d	
2;11	43	[h]	0	[ʔ]	0	[d],[t]	0			ð(1)	0	[d]2	n/d	
3	75	[h]	0	[ʔ]		[d]1	0		n/d		0	[d] [ð]	n/d	
3;1	21	[h]	0	[ʔ],[t]	6	[d],[t]	17	[s],[f],[g]	n/d		0	[d]	n/d	
3;2	38	[h]	33	[ʔ]	0	[d],[t]	0	[s]	n/d		0	[d] [tˤ]	n/d	
3;3	42	[h]	44	[ʔ],[l]	7	[d],[t],[b]	22	[s]		[d]1	25	[d]	n/d	
3;4	53	[h]	37	[ʔ]	0	[d]2	0	[s],[ð]	ðˤ(1)		n/d		n/d	
3;5	36	[h],[χ]	23	[ʔ],[hˤ]	0	[d],[t]	29	[s]	0	[ð]2	0	[d]1	25	[l]

Table 4-9: Arabic pharyngeal and emphatic consonant acquisition and substitution patterns

3. Nasals, approximants and affricate consonants

3.1 Nasals

As for her acquisition of nasal consonants, it appeared that they had been acquired and mastered early. Moreover, the phoneme /m/ stabilized after age 2;10. A

regression was noticed in her accuracy of production at 3;3 years, but it was due to a cold and the nasal was alternated with the stops [p] and [b].

3.2 Tap or flap

Overall, the acquisition of the phoneme /r/ had followed a developmental trend but never reached acquisition or even customary production. As for the substitution pattern, at the beginning of data collection the participant's production and replacements could be described as inconsistent. Longitudinally, a clear pattern emerged where /ɾ/ seemed to be realized frequently as the English [ɹ], with no sign of stabilization at the end of data collection.

3.3 Lateral approximant /l/

The phoneme /l/'s acquisition pattern could be characterized as unstable, moving from mastery to acquisition levels. However, her total accuracy was considerably high during this period, ranging from 78% to 100%, and was realized as [ɬ] at rare occurrences.

3.4 Affricate

The participant's acquisition pattern of her affricate is developmental. It had started with a 56% customary rate, and by the end of data collection it reached mastery level. As for the substitution pattern, this phoneme was mostly realized as the voiced stop [d], which is a result of the deaffrication process.

The sound /w/ was not included in the table because it mastered an stabilized at the beginning of data collection. However, the accuracy of its production reached 89% and was substituted by [ɹ] and [b] on single accounts each for a month. Thereafter, its production was 100% accurate.

Age	m	sub	n	sub	r	sub	l	sub	j	sub	dʒ	sub
2;6	89	[b],[n], [dʒ]	94	[m]	10	[ɹ],[ə],[l],[ʃ], [w],[s],[b]	86	[ɬ],[s],[ɑ:]	92	[ʔ],[l]	56	[d],[m]
2;7	89	[b],[ɹ]	n/d		0	[ɹ],[ə],[l],[d], [ɜ:],[ʊ]	92	[ɑ:]	n/d		60	[d]
2;8	89	[ɹ],[ʔ]	100		18	[ɹ],[ə],[l]	100		100		100	
2;9	83	[w]	100		10	[ɹ],[d]	78	[ɬ]	50	[ɹ],[w]	86	[d]
2;10	100		100		0	[ɹ],[m]	100		100		0	[d]2
2;11	100		100		14	[ɹ],[n]	91	[ɬ]	83	[ɹ]	80	[d]
3	100		100		22	[ɹ],[n],[b]	87	[ɬ]	100		100	
3;1	100		100		35	[ɹ],[ə]	100		100		87	[d]
3;2	100		100		26	[ɹ]	89	[ɬ]	57	[ɹ], [ʔ],[l]	83	[d]
3;3	78	[p],[b]	100		32	[ɹ]	78	[ɬ]	50	[ʔ],[l],[d]	82	[d]
3;4	100		100		45	[ɹ]	100		100		80	[d]
3;5	95	[l]	94	[ʒ]	31	[ɹ],[ɔ:],[m]	88	[ɬ]	86	[l]	90	[ð]

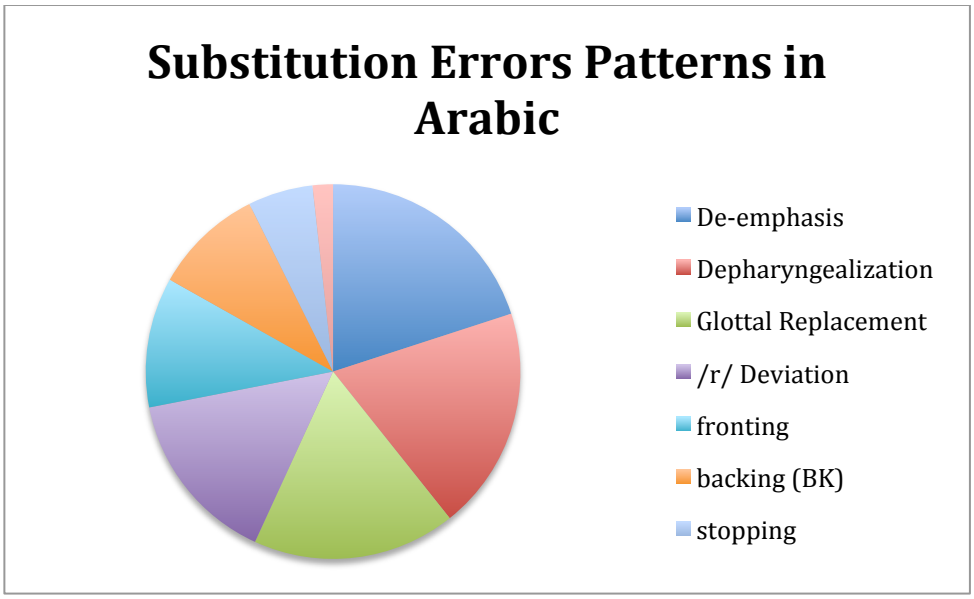
Table 4-10: Arabic nasal, tap/flap, approximant and affricate consonants acquisition and substitution patterns

4.1.2.3 Error analysis

1. Type analysis

1.1 Substitution errors

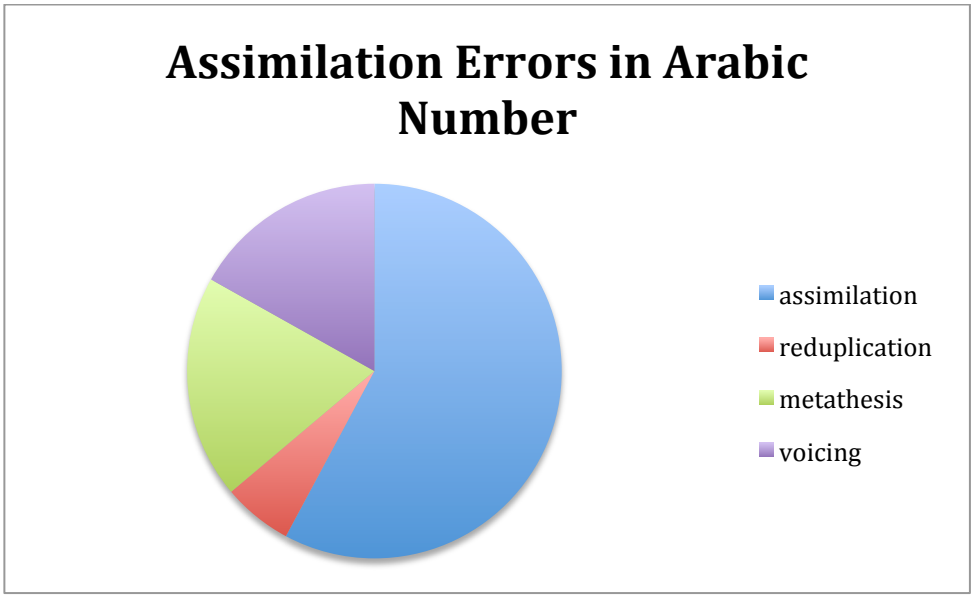
Graph 4-4 illustrates substitution error types in Arabic. De-emphasis, depharyngealization and glottal replacement occurred with comparable high frequency, counting for 20%, 19% and 18% of total substitution error patterns respectively. In addition, /ɾ/ deviation and fronting occurred in moderate frequency, reaching 15% and 11% respectively, while backing, stopping and lateralization error patterns scored 9%, 6% and 2% of total error patterns respectively.



Graph 4-4: Substitution error patterns in Arabic

1.2 Assimilation errors

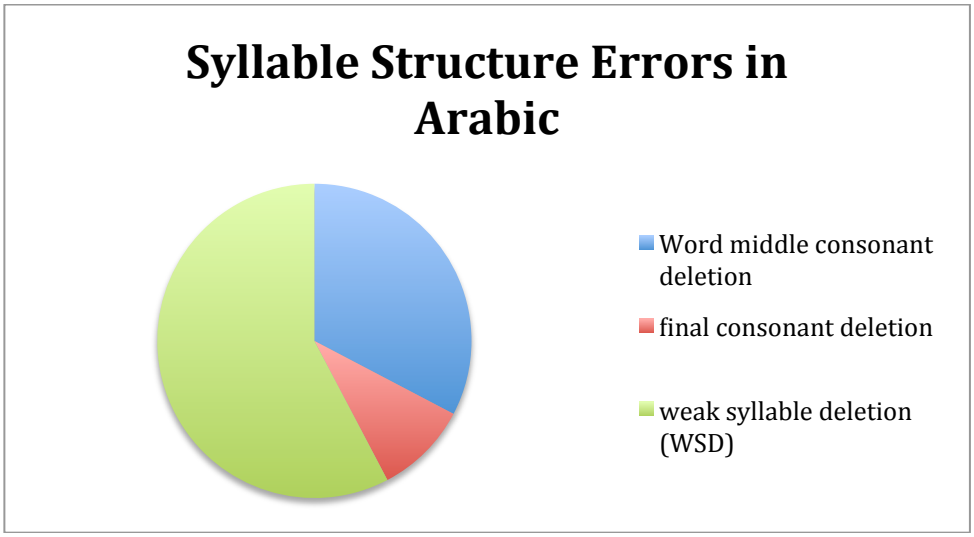
The most frequent assimilation error patterns were assimilation, metathesis, voicing and reduplication, scoring 58%, 19%, 17% and 6% of total assimilation errors respectively.



Graph 4-5: Assimilation error patterns in Arabic

1.3 Syllable structure errors

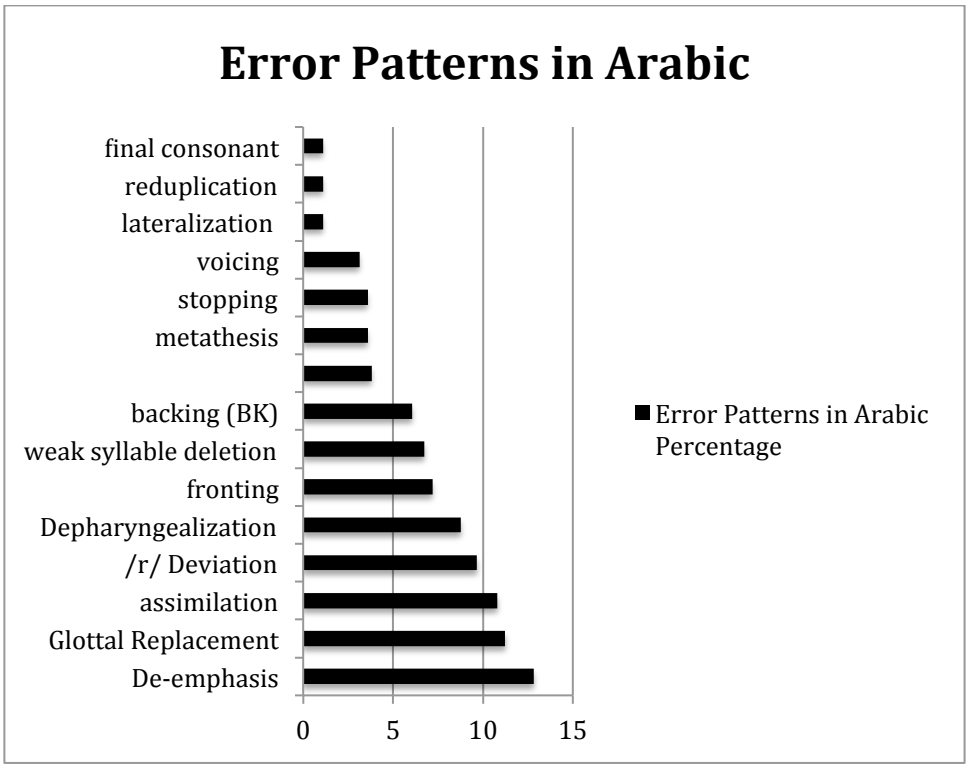
Three error patterns of syllable structure errors were identified in the participant's Arabic speech data. Weak syllable deletion had the highest frequency percentage of 58%, followed by word middle consonant deletion with a frequency score of 33%, while final consonant deletion occurred in about 10% of total syllable structure Arabic errors.



Graph 4-6: Syllable structure errors in Arabic

1.4 Overall comparison in Arabic

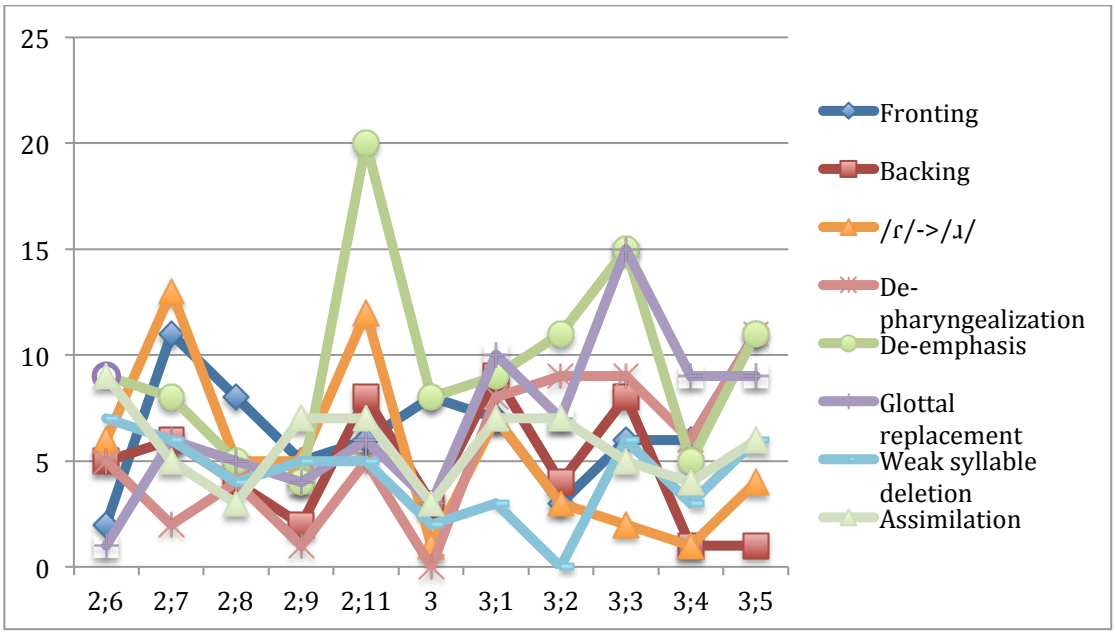
A comparison of error patterns in Arabic is illustrated in Graph 4-7. The highest frequently occurring error patterns were de-emphasis, glottal replacement and assimilation. Medium occurring error patterns were /ɾ/ deviation, de-pharyngealization, fronting, WSD and backing, while the least frequently occurring errors were lateralization, reduplication and FCD.



Graph 4-7: Overall error patterns in Arabic language

2. Frequency analysis

Graph 4-8 demonstrates the frequency of error pattern occurrences over the period of data collection. There seems to be fluctuation of error occurrence rates that was not affected by age. Glottal replacement, fronting, de-pharyngealization and de-emphasis error patterns displayed an increased rate of occurrence over time, while backing, /ɾ/ deviation, WSD and assimilation error patterns frequency seemed to drop at the end of data collection after a noticeable increase.



Graph 4-8: Longitudinal frequency analysis of error patterns in Arabic

4.1.3 Comparison between English and Arabic phonological acquisition

4.1.3.1 Percentage Consonant Correct (PCC)

A glance at Table 4-11 reveals a significantly higher PCC rate in English than Arabic during the first and last months of data collection. However, there seems to be a marginally higher improvement percentage for Arabic, with 1.8% more than English.

PCC	English	Arabic
2;6	84%	55.5%
3;5	92.8%	66%
Average	88%	60%

Table 4-11: English and Arabic PCC results

4.1.3.2 Phonemic repertoire

MF	English			Arabic		
Age	Mastery production (>90%)	Acquisition production (75-89%)	Customary production (50-74%)	Mastery production (>90%)	Acquisition production (75-89%)	Customary production (50-74%)
2;6	/p/, /b/, /t/, /d/, /k/, /m/, /n/, /ŋ/, /f/, /ʃ/, /j/, /l/, /ʧ/, /w/	/g/, /s/, /ɹ/	/v/, /z/	/b/, /t/, /d/, /k/, /g/, /n/, /f/, /ʔ/, /w/	/m/, /l/	/ʤ/, /ħ/
2;7	+/ʤ/					
2;8	+/g/-				+/ʤ/	/ħ/
2;9	+/ɹ/		/z/	+/ʃ/	+/s/, +/θ/	
2;10				+/j/, +/m/		
2;11						
3						
3;1	+/s/	/z/	/ð/			
3;2					+/ʃ/	/χ/, /j/
3;3		/g/				
3;4						
3;5				+/ʤ/	+/j/, +/χ/, +/ð/,	

Table 4-12: English and Arabic phonemic inventories
Note: +stabilized for some time, *highlight=fluctuation

1. Plosives

Table 4-12 demonstrates high levels of attainment and accuracy of MF's production of her English and Arabic plosives. All plosives were mastered at the beginning of data collection except for the phoneme /g/, which demonstrated different acquisition patterns for English than Arabic. The phoneme /g/ was mastered and stabilized at the beginning in Arabic, while it fluctuated between acquisition and mastery level in her English production. Moreover, no comparable patterns of substitution across her languages could be discerned.

2. Fricatives

A divergence of fricative acquisition pattern across languages was observed. Overall, the participant mastered more fricatives in English than in Arabic. The phoneme /f/ was mastered early in both languages, while /s/ was only mastered and

stabilized in English at age 3;1. Moreover, /ʃ/ acquisition fluctuated between mastery and acquisition levels but was mastered early in English. The phoneme /z/ reached an acquisition level at age 3;1 in English only. For substitutions, two phonemes /s/ and /z/ were frequently realized as [θ] and [ð] respectively in both Arabic and English. For interdental acquisition, in Arabic both interdentals were acquired at the end of data collection period, but that was not the case in English. It is important to point out to two factors that may have caused that discrepancy across languages:

a. She was able to produce the target value in English for several months, and it was part of her phonemic inventory at the end of data collection; however, she tended to substitute it with sound [d]. This preference may be dialectal. Moreover, some scholars suggest that the functional load of interdental in English is low, even though its frequency of occurrence is very high because the substitution of interdental /ð/ with [d] does not result in miscommunication and the child will still be understood. Additionally, it mainly exists 'in a small class of frequent words and subsequently enters into a small number of minimal pairs' (Ingram, 1989, p. 218).

b. She could only produce the target value a few times in Arabic; however, there were not enough data to support her total production, with only few words used with this phoneme. Over the interim of data collection, seven words were produced that included these sound, and the majority of these words were demonstrative pronouns. She managed to reach the target value five times out of eight.

3. Approximant and laterals

3.1 Arabic /ɾ/ and English /ɹ/

The acquisition of these phonemes took different acquisition paths across languages. English /ɹ/ was acquired at the beginning of data collection and was both mastered and stabilized at 2;9 years. However, Arabic /ɾ/ did not reach customary levels at any point during this year and was replaced consistently by English [ɹ].

3.2 /l/

Lateral approximant /l/ exhibited different acquisition trajectory cross-linguistically. While it was mastered at the beginning of data collection in English, it reached an acquisition level in Arabic during the data collection period. In addition, the dark / ɬ/ in English was not separately calculated because the participant did not make any errors and it was mastered along the clear /l/.

4. Nasals

The acquisition of the nasal consonants is comparable across languages and they were mastered by 2;10 years.

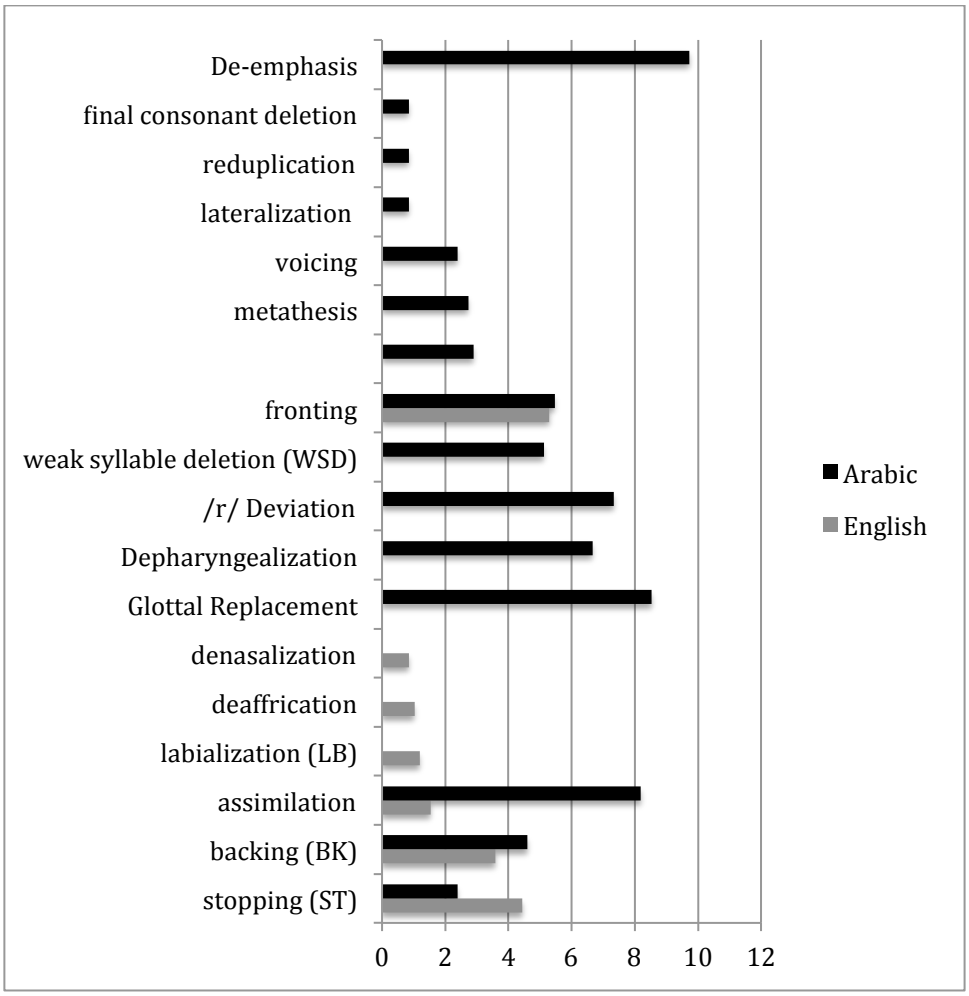
5. Affricate

As for the acquisition of the affricate consonant /dʒ/, it was mastered and stabilized far earlier in English than in Arabic. Few substitutions took place in the process of its acquisition in English; however, it was consistently deaffricated into [d] in Arabic.

4.1.3.3 Error analysis

1. Type analysis

Graph 4-9 demonstrates the frequency of error patterns across the participant's languages. Overall, it is clear that the participant had dramatically higher percentages of error patterns in Arabic than English. Fronting, assimilation, backing, and stopping were identified in both languages. Language-specific error patterns were also identified. For example, labialization, deaffrication and de-nasalization errors only affected the participant's production of English, while de-emphasis, glottal replacement, de-pharyngealization, /r/ deviation, weak syllable deletion, middle consonant deletion, final consonant deletion, metathesis, voicing, lateralization, and reduplication were recognized in the Arabic data only.



Graph 4-9: Comparison between English and Arabic error patterns

2. Frequency analysis

The findings of frequency analysis reveal similar tendencies across the participant's languages. Fronting error patterns demonstrated increased occurrences, while backing and assimilation error patterns showed noticeable decreases in frequency in both English and Arabic production at the end of data collection. Moreover, stopping errors exhibited an increase in English while similar processes like glottal replacement in Arabic were on the rise.

4.2 Summary and discussion

4.2.1 Summary

4.2.1.1 Segmental acquisition

1.1 Transfer

During segmental acquisition, evidence of transfer was observed mainly through the production of two of Arabic phonemes /ɾ/ and /l/. The observed transfer was unidirectional, affecting Arabic production only. Arabic phoneme /ɾ/ was realized 70% of its total production largely as English approximant /ɹ/. Occasionally, /ɾ/ is replaced by a long vowel in a postvocalic environment, reflecting the standard pronunciation of this phoneme in non-rhotic Berkshire English variety. For example, [ʃokɹən], /χɪnziːɾ/->[χɪnzɪə], /moɾdʒan/->[məːdʒan], /gɜɾd/->[gɜːd], /ɾiːʃah/->[ɹiːʃah]. Longitudinally, the participant seemed to be aware of the distinction between the two sounds and was able to produce the target Arabic /ɾ/ 30% of total production at the last month of data collection. This rise in differentiation is explained by the attainment of additional input in English and Arabic over the period of acquisition.

In addition, the production of phoneme /l/ in Arabic exhibited some modification and was substituted by the English dark /ɬ/ at very low frequency occurring in less than 10% of total production in two different contexts:

(1)

[bəttɛgaɬi] -> / boɾtuqali/ orange color

[zəɬɬɑniːn] -> / zəʕlaniːn/ upset (plural)

(2)

[ɹədʒaɬ] -> /ɾədʒal/ man

[ðejɬ] -> /ðejl/ tail

For the first context (1), the occurrence of pharyngealized [lˤ] for the target Arabic /l/ can be attributed to anticipatory effect rather than transfer. The target pronunciation for the word 'upset' in Arabic is /zəʕlaniːn/, in which it was realized as [zəlˤɑniːn] by the participant. In that context, the pharyngeal /ʕ/ was deleted but its characteristics (pharyngealization) were extended to the adjacent consonant /l/.

In terms of the context (2), the transfer of the English allophonic rule occurred with low frequency and affected only 10% of total target production. This transfer appeared to be unidirectional, affecting her Arabic production only. Higher exposure of English may have caused the Arabic postvocalic /l/ to be produced in similar quality of the English dark /ɬ/. This substitution pattern appeared to be systematic at first even though it was infrequent. Longitudinally, the participant was able to associate the allophonic rule that governs the distribution of clear and dark /ɬ/ to her English production, and the intensity of transfer was reduced. This provided evidence for grammatical separation.

The evidence of transfer between the participant's two languages appeared to occur with relatively low frequency, supporting the findings of previous research (Genesee *et al.*, 1995; Fabiano & Goldstein, 2005; Schnitzer & Krasinski, 1994). In addition, other shared and unshared consonants were not affected, indicating differentiation of the phonological systems of the participant's languages, which is supported by previous research (Paradis & Genesee, 1996; Fabiano-Smith & Goldstein, 2010).

b. Acceleration and delay

Some of the phonemes were found to be mastered earlier than monolinguals of English by the participant. For example, /l/ was among the earlier acquired sounds. Compared to McIntosh and Dodd (2008), children produced /l/ with 75% accuracy between two and three years old. Moreover, other English studies have classified the /l/ sound as an intermediate sound acquired between three and four years. The participant had acquired and mastered this phoneme at the beginning of data collection when she was 2;6 years old. In Arabic, monolingual children seemed to master this phoneme early on, with 90% accuracy by around ages two to four (Owaida, 2015; Alqattan, 2015). However, her production underwent reversal from mastery to acquisition levels. At the end of data collection, the participant reached an acquisition level. Therefore, her acquisition may be interpreted as a sign of delay compared to Arabic monolinguals.

In addition, the following phonemes were mastered in Arabic by the participant between 2;6 and 3 years: plosive /b, t, k, ʔ/, nasals /m, n/ and fricatives /f, h/. In comparison to Alqattan's (2015) study, the participant appeared to have an accelerated acquisition of /b, t, n, f, h/. Moreover, she had acquired the following phonemes between 3;1 and 3; 6 and were classified as intermediate sounds: plosive /d, g/ and affricated /ʤ/. The age of acquisition of /d, g/ corresponds to the age of acquisition reported for Arabic-speaking children in (ibid). However, the mastery of the affricate /ʤ/ at this age is considered to be accelerated, as it was reported to be a late acquired sound by several Arabic studies. On the other hand, the participant did not seem to master the fricative /s/ and seemed to have an acquisition production level, whereas it was reported to reach a mastery level by participants in Alqattan's

(2015) study. To conclude, it seems that the participant has an accelerated inventory at the early sound level compared to Arabic monolinguals. However, after she reaches three years old, her inventory seems to correspond to Arabic monolingual-speaking children.

In English, the following segments were mastered early by the participant between 2;6 and 3: plosives /p, b, t, d, k/, nasals /m, n, ŋ/, approximants /l, ɹ, j/, fricatives /f, ʃ/ and affricates /tʃ, dʒ/. Few missing sounds from her inventory at the mastery level were alveolar fricative consonants /s, z/ and interdental consonants /θ, ð/. In comparison to English monolingual acquisition as reported in McIntosh and Dodd's (2008) study, the participant's production is accelerated for the following phoneme: fricatives /f, ʃ/, affricates /tʃ, dʒ/ and the approximant /l, ɹ/. Nonetheless, a deceleration of production for the phonemes /g/ and /s/ was observed. This delay in the acquisition was overcome after the participant turned three years old, in which the production of /g/ and /s/ reached mastery. Moreover, /z/ was not mastered at any point during the data collection period. To conclude, the participant's English inventory is accelerated in comparison to English monolinguals at the early stage of acquisition, while the rate of her acquisition corresponds to English monolinguals at the intermediate acquisition stage.

It is worthy to point out that the participant had an accelerated production for the approximant /ɹ/ before age three, which was reportedly a late acquired sound after four years by English monolingual children. Interestingly, in Arabic, the corresponding sound was not mastered by the participant during the data collection period. It was reported as an intermediate acquired sound by some Arabic studies but not by Alqattan's (2015) study. The participant's substitution pattern for the Arabic /ɾ/ did not affect her communication in Arabic.

4.2.1.2 Error patterns

1. Language specific error patterns

Two of the error patterns frequently observed in the participant's production in Arabic were language specific. They will be discussed in detail in the following paragraphs.

De-emphasis is considered the most frequently occurring error pattern observed in the speech production of Arabic monolingual children. Emphatics are phonemes that 'are produced with a secondary articulation in which the root of the tongue is retracted toward the back wall of the pharynx' (Dyson & Amayreh, 2000). Developmental data of Arabic-speaking children reported emphatics among the late acquiring sounds (Alqattan, 2015; Owaida, 2015). This error pattern was found to be one of the most occurring error patterns in MF's production and accounted for almost 12% of her total error patterns. Longitudinally, the intensity of this error did not decrease. For example, the participant de-emphasized 80% of target emphatics between 2;6 and 2;7, while the frequency of this error reached 90% at the last month of data collection. On the other hand, in Alqattan's (2015) study the frequency of this error pattern demonstrated a steady decrease from 49% to 11% by Arabic monolinguals between the following age groups: 2;4-2;7 and 3;4-3;7 years old respectively. Convergence is observed in the higher frequency percentage of this error's occurrence compared to other error patterns by Arabic monolinguals. However, divergence from the monolingual norm is observed in terms of rate of acquisition, in which Arabic monolinguals were able to acquire emphatics at an accelerated rate compared to the participant.

Glottal replacement is another frequent error pattern reported in the speech sample of the participant. It accounted for around 11% of total error patterns. Its frequency seemed to go through periods of fluctuation throughout the data collection, with no sign of stabilization at age 3;5. Most glottal replacement errors were substitutions for pharyngeal. Nevertheless, the analysis of the speech data of Arabic monolingual children between 1;4 and 3;7 years old revealed that this error pattern counted for only 1% of errors by those children and was classified as a rare error pattern (Alqattan, 2015).

2. Error patterns across languages

Table 4-13 illustrates the participant's error patterns across monolingual speakers in English and Arabic. In comparison to monolingual production, MF seemed to have fewer types of error patterns across both languages. However, this comparison should be approached with caution for several reasons. First, Table 4-13 synthesizes the results of several studies across different dialects that may use different methodological and sampling criteria, which was previously discussed. Another concern touches on the overall impression from Table 4-13: that the participant had an accelerated acquisition in comparison to monolinguals. Even though the analysis indicates fewer error types in comparison to monolinguals, this does not necessarily imply less frequency. Therefore, it is crucial to discuss in detail the participant’s results against each error type across her languages in comparison to monolingual acquisitions. The aim of the following paragraphs is to further discuss the participant's error patterns in comparison to monolingual norms.

Age	2;6 -2;11		3;0- 3;5	
Language	E	A	E	A
1. Substitution error patterns				
Fronting	MF	MF	MF	MF
Backing	MF	MF		MF
Dentalization				
Stopping	MF		MF	
Gliding				
De-affrication				
De-emphasis		MF		MF
Lateralization of /r/				
/ɾ/ ->/ɹ/		MF		MF
Glottalization		MF		MF
2. Assimilation				
De-voicing				
Voicing				
Assimilation		MF		MF
3. Syllable error patterns				
Final consonant deletion				
Cluster reduction				
Weak syllable deletion		MF		MF

Table 4-13: MF's error patterns across English and Arabic speaking children

The highest occurring type of errors patterns observed in the participant's production is substitution errors. Some of the error patterns reported in the participant's production did not converge to monolingual norms in both languages. For example, the participant's acquisition trajectory of the phoneme /r/ did not follow that of either English nor Arabic monolingual children. Lateralization and gliding error patterns were found to be scarce in the participant's production of English and Arabic. This could be explained by the fact that the English approximant /ɹ/ was among the early acquired sounds in her phonemic inventory. Her acquisition is accelerated compared to English monolingual speakers for this particular segment (McIntosh & Dodd, 2008). She did not need to use either error pattern in her production, as she often substituted the English /ɹ/ for the Arabic /ɾ/, which was

explained in detail under phonemic acquisition as an evidence of phonological transfer.

As far as fricative consonants production is concerned, MF results reveal different patterns across her languages. Stopping error pattern was documented in much greater frequency in her English compared to her Arabic production, and it was classified under the most frequently occurring error patterns in English, while it was considered one of the occasional errors in her Arabic production. Interestingly, both stopping errors across the participant's two languages seem to increase marginally over time. This increase could be explained in terms of the different substitution mechanisms that the participant deployed in the production of fricatives in English and Arabic as well as the size of the fricative inventory in each language. In her production of fricative consonants in Arabic, the most frequent error patterns reported were assimilation, fronting and backing. However, in her English production of fricative consonants, stopping was the most frequent error pattern reported. In addition, there are cross-linguistic differences in terms of the size of fricative inventory. In Arabic, fricatives consist of eleven segments: f, θ, ð, s, z, ʃ, χ, ʁ, ħ, ʕ and h, seven of which are shared with English. The substitution pattern for the seven fricatives took different trajectories except for /z/, which was realized as the voiced interdental /ð/ in both languages. Moreover, the production of interdentals in English is influenced by dialectal variation rather than stopping errors. Arabic specific phoneme such as /ħ/ realized as [h] and /ʕ/ realized as [ʔ] were categorized as backing and glottal replacement errors respectively, which could have affected the results. To conclude, the frequency of stopping error patterns correspond to monolingual children across her languages.

Similarities and differences of the production of fronting errors by the participant were reported cross-linguistically. Similar numbers of fronting errors in both English and Arabic production were noted. However, the frequency of the error occurrence in relation to other errors in each language shows big differences. For example, fronting error patterns were the most frequently occurring error pattern in the participant's production of English, while its frequency was average in Arabic. This difference could reflect monolingual tendencies across both of her languages, where this error was found to be produced at a higher frequency by English than Arabic children.

Assimilation error pattern had a medium frequency of occurrence in the participant's English production. This error pattern was consistent in the participant's production up to the end of data collection with an overall decline associated with few fluctuations. Regarding her Arabic production, this error pattern occurred at a higher frequency compared to her English production and to the total error patterns. Comparable to her English, there seem to be an overall decline in this error production, associated with a sharp frequent fall. The frequency of this error production corresponds to English monolingual data, even though it persisted after the age of three with a very low frequency. On the other hand, there seems to be a deceleration in her production compared to Arabic monolinguals regarding this error, where it was not classified as an age-appropriate error by monolingual speakers and it was persistent in the participant's speech until the end of data collection period.

The analysis of MF's production indicated a similar number of occurrences of backing error across her languages. Nonetheless, this error was ranked higher in her English than Arabic production in relation to total error patterns. This result is not surprising since the total number of her errors in Arabic is much higher than in

English. In addition, there is a decrease of the production of this error in both English and Arabic. Comparing the participant's result to monolingual production, it is concluded that her acquisition might exhibit some signs of delay across her languages as far as backing error is concerned.

The analysis of the participant's English production demonstrated that deaffrication, weak syllable deletion and cluster reduction errors were among the least frequently occurring errors throughout the data collection period, scoring 2% each of total errors. Comparably, her Arabic production exhibited similar trends, except for weak syllable deletion error pattern, which occurred at medium frequency until the end of data collection. In conclusion, the participant's production seems to be accelerated than that of monolingual children in regards to these errors, except for weak syllable deletion error reflected in her Arabic speech production, which demonstrates a case of delay.

Generally speaking, MF's production of errors follows the same pattern as those of English and Arabic monolingual children under three years old. After she turned three years old, the acquisition rate of her Arabic language seems to be slower compared to monolinguals, exhibiting an overall delay of acquisition and higher frequency of error production.

4.2.2 Discussion

The aim of this section is to address the main research question of evaluating the extent of cross-linguistic interaction in the phonological acquisition and development of simultaneous bilingual children. Three criteria have been considered to assess the prospect of cross-linguistic interaction in the participant's speech

production. The findings indicate the presence of all three manifestations; acceleration, delay, and transfer.

Acceleration and delay are quantitative manifestations of interaction that are assessed against monolingual norms. The participant's acquisition pattern differed cross-linguistically, and instances of acceleration and delay were reported. The participant's acquisition of English is observed to be accelerated. Her Arabic acquisition followed monolingual norms only when she was under three years old. The data exhibits an overall delay of her Arabic acquisition after that age compared to monolinguals. The reported divergence of the participant's acquisition from Arabic monolinguals after the age of three could be explained by the fact that inventories of monolingual speaking children across different languages share some similarities at the early stages of acquisition; however, as the children's inventories expand, variability becomes more pronounced (Rice & Avery, 1995). In addition, the participant's error pattern frequency in Arabic is higher compared to monolingual children. For example, the participant was observed to use some error patterns like assimilation and weak syllable deletion at remarkably higher frequencies and over the appropriate age period.

The last indicator of interaction according to Paradis and Genesee's (1996) model is transfer. Transfer was only observed in her production of Arabic and affected the production of two consonants: /ɾ/ and /l/. The application of the English allophonic rule of /l/ was observed only episodically and was overcome shortly, which could be the result of an increase of language differentiation over time. The other case of transfer is characterized by systemic replacement of the Arabic /ɾ/ by English [ɹ]. This case was observed frequently over the whole period of data collection, with a marginal decrease at the end of data collection.

Evidence of the three manifestations of interaction was found in the participant's data; however, delay appears to be caused by other environmental factor and not by interaction. Delay is observed in her Arabic PCC reflects language exposure patterns in that language rather than cross-linguistic interaction, given that her English PCC score was accelerated compared to English-speaking monolinguals.

5 Case study (SF)

5.1 Results

This section is a detailed account of SF's consonant acquisition throughout the data collection period. The results are divided into three different sections: (1) English data, (2) Arabic data and (3) a comparison between English and Arabic phonological development.

5.1.1 English data

Segmental production of the participant was examined for matches and substitutions. Three measures were considered: PCC, phonemic repertoire and error analysis.

5.1.1.1 Percentage consonant correct (PCC)

The participant's PCC was calculated at two different points: when the participant was 2;6 and at the last month of data collection period when she reached 3;5 years old. The average percentage was computed by adding the PCC percentages of the first month and last month of data collection and divided by two. The results are presented below:

PCC	English
2;6	72.2%
3;5	91.2%
Average	81.7%

Table 5-1: English PCC

5.1.1.2 Phonemic repertoire

1. Plosives

SF's phonemic inventory demonstrated that she had acquired her stops early, at the beginning of data collection.

Age	p	sub	b	sub	t	sub	d	sub	k	sub	g	sub
2;6	88	[f]	100		81	[k]	77	[s], [tʃ]	92	[t]	71	[k]
2;7	66	[b]	100		100		80	[t]	100		33	[k]
2;8	100		100		100		87	[t]	100	100	100	
2;9	100		100		100		75	[t]	100	100	100	[1]
3	100		100		100		100		83	[t], [k]	50	[k]
3;1	88	[f]	87	[f]	100		88	[t]	75	[tʃ], [g]	50	[k]
3;2	100		88	[p]	100		90	[b]	86	[t]	60	[k]
3;3	66	[f], [k], [b]	88	[p]	100		100		100	100	100	
3;4	100		95	[p]	100		100		100		75	[k]
3;5	88	[f]	100		93	[tʃ]	83	[f]	87	[t], [dʒɪ]	87	[k]

Table 5-2: English plosive consonants acquisition and substitution patterns

Table 5-2 demonstrates the age of acquisition of English plosives during the data collection period. Her acquisition pattern went through different phases. Before the participant turned three, she appeared to master the following plosives: /p/, /b/, /t/ and /k/. However, after she turned three, the acquisition of phonemes /p/, /b/ and /k/ fluctuate between mastery and acquisition levels. As for the substitution patterns, few substitutions were made, and it appeared that they were on their way to stabilization. Interestingly, the phoneme /b/ was devoiced and realized as /p/ occasionally.

On the other hand, phoneme /d/'s acquisition pattern is developmental. Though SF did not master it at the beginning, she reached mastery level after three years only to drop to acquisition level at the end of data collection. As for a substation pattern, it occurred in alternation with its voiceless counterpart [t] occasionally.

Phoneme /g/ appeared to have the lowest percentage across all the plosives. It alternated with its voiceless counterpart /k/ for several months and reached an acquisition level at the end of data collection period.

Even though SF's overall accuracy of her plosive is high, a sporadic overlap of the voicing contrast was evident.

2. Fricatives

Table 5-3 demonstrates the acquisition pattern of fricative consonants by SF. At the end of data collection, most of the fricatives were acquired, except for /θ/ and /z/. Her acquisition pattern could be described as developmental; at the beginning of data collection period, none of her fricatives reached acquisition level, but after periods of fluctuations, stabilization was observed. The earliest acquired fricatives appeared to be /f/, /s/ and /ʃ/ and were mastered at the end of data collection. The phonemes /v/ and /z/, on the other hand, were not mastered but seemed to reach acquisition level at the end. There was not enough data to conclude whether /v/ stabilized because she only produced it correctly in a single occurrence. As for the substation pattern, it seemed that these fricatives were frequently devoiced to their voiceless counterpart /f/ and /s/. In addition, both of the fricative interdentals went through periods of fluctuations, but only /ð/ was mastered at the end of data collection. In terms of substitution patterns, /θ/ appeared frequently in alternation with the alveolar voiceless plosive [t], while /ð/ alternated with alveolar voiced plosive [d].

Age	f	sub	v	sub	θ	sub	ð	sub	s	sub	z	sub	ʃ	sub
2;6	60	[ʃ], [b]	33	[g], [f]	0	[t]1	0	[d]1	87	[ʃ]	37	[s], [ð]	33	[s], [d], [tʃ]
2;7	66	[b]	100	[1]	100	[1]	0	[d]1	100		50	[s], [ʃ]	50	[s] 1
2;8	100		75	[f]	0	[t]2	100	1	100		n/d		n/d	
2;9	100		50	[f]	0	[t]1	n/d		100		0	[f], [ð]	n/d	
3	83	[ʃ]	66	[d]	33	[s], [ʃ]	50	[d]1	100		86	[s]	83	[tʃ]
3;1	100		100		66	[ʃ]	40	[d]	80	[t], [z]	50	[s], [ts], [θ]	100	
3;2	100		100	(2)	33	[ʃ],	100	[1]	71	[ʃ], [z]	100		100	

						[t]								
3;3	87	[d]	50	[p], [ɹ]	50	[t]1	50	[d]1	100		80	[s]	83	[tʃ]
3;4	87	[ʃ], [θ]	66	[z]	50	[t]1	60	[d]	89	[θ]	0	[ʃ], [s]	100	
3;5	100		100	[1]	50	[s], [t]	100		95	[k]	75	[s]	100	[2]

Table 5-3: English fricative consonants acquisition and substitution patterns

3. Nasal, approximant and affricate consonants

3.1 Nasal and affricate consonants

Nasals had been acquired and mastered since the beginning of data collection. Rare substitutions were observed for the phoneme /n/. This substitution took place in the winter season and may have been caused by a cold.

In addition, affricate consonants seemed to be mastered and stabilized early. However, phoneme /dʒ/'s acquisition level dropped to customary at the end of data collection. This drop could be attributed to limited production opportunities; the participant only uttered three lexical items of the target sound, with two of them corresponding to the target pronunciation.

3.2 Approximants

/ɹ/

SF's acquisition pattern of the approximant alveolar /ɹ/ could be characterized as developmental. In terms of acquisition, her production corresponded to customary levels at 2;6 while reaching mastery at the end of data collection. Its production infrequently alternated with phonemes [l] and [r]. It alternated with [l] at the middle and final positions but never at the beginning of words (e.g. [fɪŋgəl] finger and [vɛli]

very). Moreover, it appeared that the substitutions of /ɹ/ into [r] was also sensitive to the word position and occurred frequently post-vocalically (e.g. [pɜrpl] purple, [kærət] carrot, [pʌtərflaɪ] butterfly) and only once at the initial in the word [ræbət] rabbit.

Lateral approximant /l/

The phoneme /l/ was mastered and stabilized early. Its target production was realized as [ɹ] at sporadic occurrences and was mainly the result of assimilation processes.

Age	m	n	sub	ŋ		ɹ	sub	l	sub	j	sub	tʃ	dʒ	
2;6	100	100		100		66	[f], [r], [l]	92	[k] clr	100		100	100	
2;7	100	100		100		75	[l]	100		100		100	100	
2;8	100	100		100		83	[l]	100		100		n/d	100	
2;9	100	100		100		100		83	[ɹ]	100		n/d	100	
3	100	88	[w]	100		87	[l]	71	[ɹ]	95	[ɹ]	100	100	
3;1	100	88	[m]	100		85	[l]	100		100		100	100	
3;2	100	100		100		33	[r], [l]	100		100		100	90	[ʒ]
3;3	100	100		100		66	[r]	100		100		100	100	
3;4	100	100		100		92	[ʃ], [r]	100		100		100	100	
3;5	100	100		100		92	[d], [l]	100		100		100	66	[k]

Table 5-4: English nasal, approximant and affricate consonants acquisition and substitution patterns

5.2.1 Error analysis

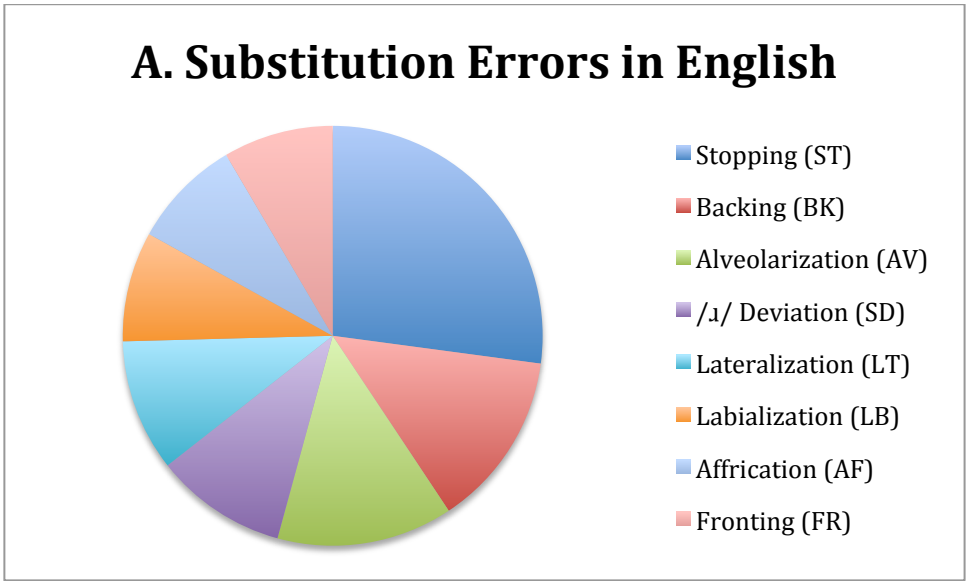
Two types of error patterns analysis were selected to establish the overall percentage of error occurrences and to provide longitudinal data of error frequency over time. The first set of analysis is labelled type analysis while the other is frequency analysis.

1. Type analysis

It is important to note that data was not collected for two months during 2;10 and 2;11 due to the participant's mother's busy schedule and travelling.

1.1 Substitution errors

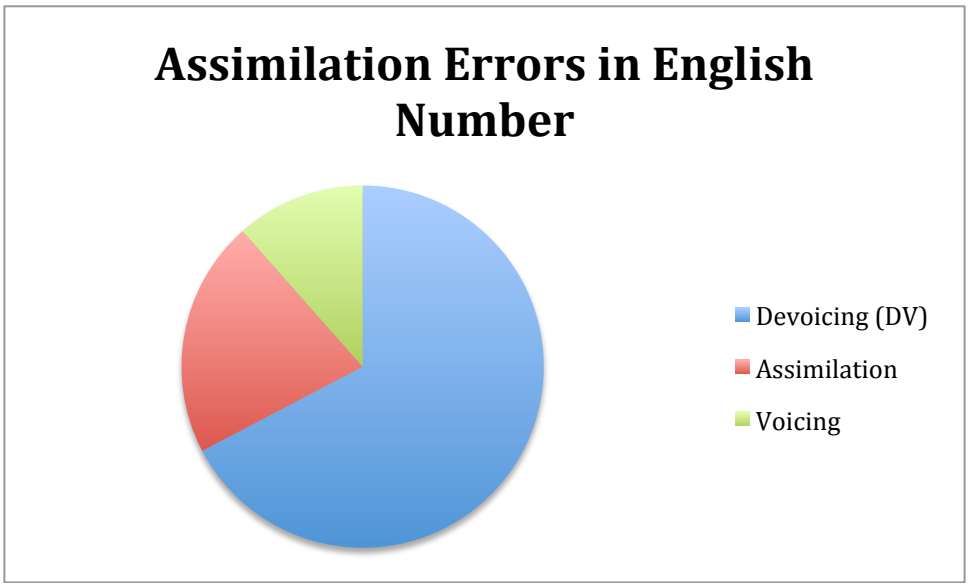
Graph 5-1 illustrates the frequency of substitution error patterns in English. The most frequent error pattern was stopping, accounting for 27% of total substitution patterns. Backing and alveolarization errors exhibited similar occurrence rates of 14%. Interestingly, /ɹ/ related production errors, such as /ɹ/ deviation and lateralization frequency rates, were equivalent and reached 14% each. In addition, the least frequent substitution errors were labialization, affrication and fronting, each scoring 8% of total substitution error patterns.



Graph 5-1: Substitution error patterns in English

1.2 Assimilation errors

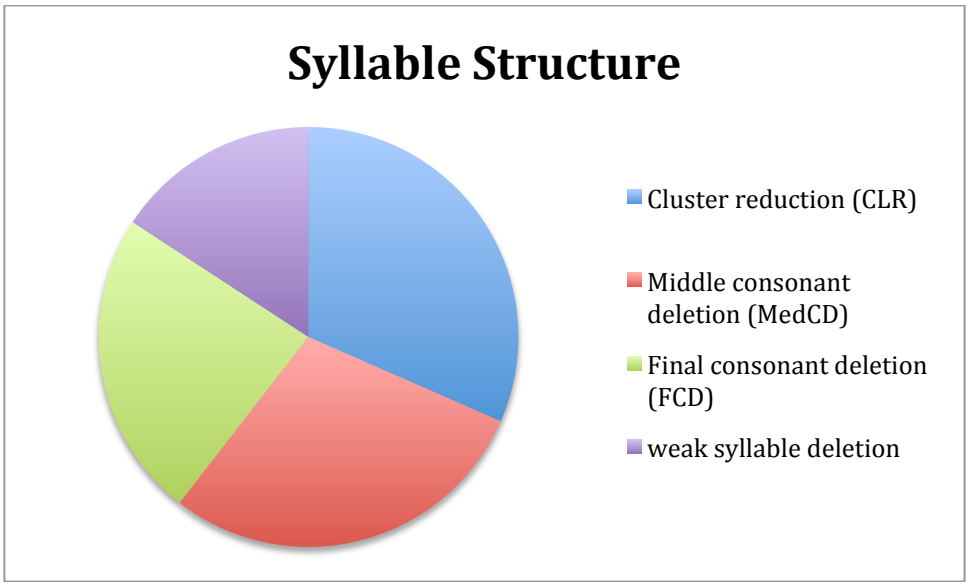
Graph 5-2 demonstrates the types of assimilation errors identified in the participant's English throughout the data collection period. Devoicing error pattern was the most frequent assimilation error, scoring 67% of total assimilation errors. Assimilation error pattern frequency of occurrence scored 21%. The least frequently occurring assimilation error was voicing, reaching 12% of total assimilation errors.



Graph 5-2: Assimilation error patterns in English

1.3 Syllable structure errors

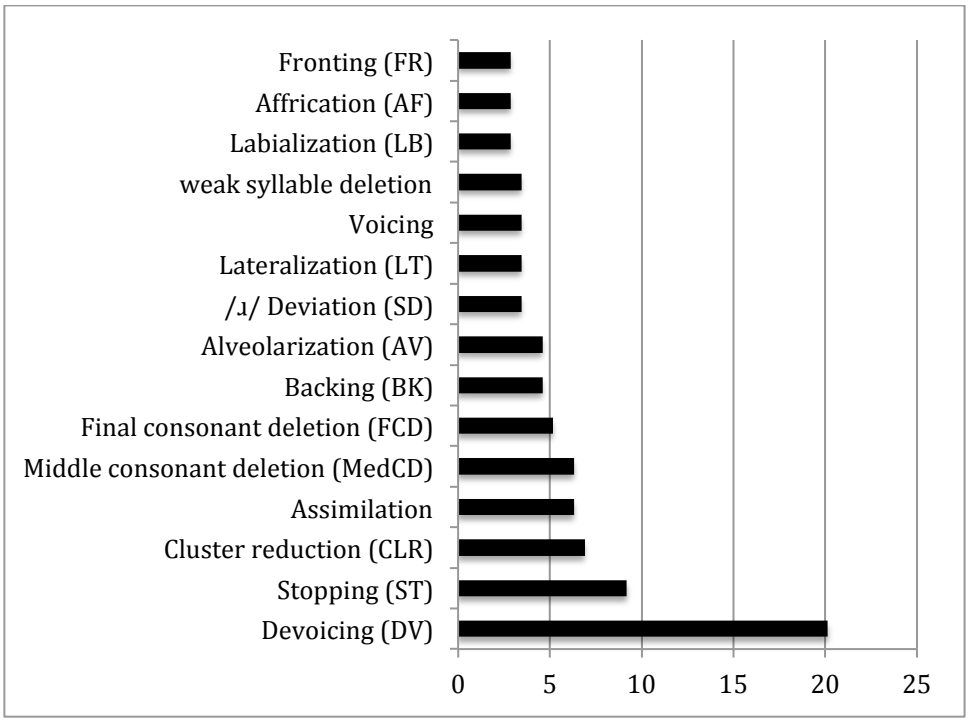
Graph 5-3 shows the frequency of occurrence of the syllable structure error patterns. The most frequently occurring error pattern was cluster reduction, accounting for 32% of total syllable structure errors. Consonant deletion errors occurred at 29% and 24% for middle and final consonant deletion respectively. The least frequently occurring syllable structure error pattern identified was weak syllable deletion, counting for 16% of total syllable structure errors.



Graph 5-3: Syllable structure errors in English

1.4 Overall comparison of error patterns in English

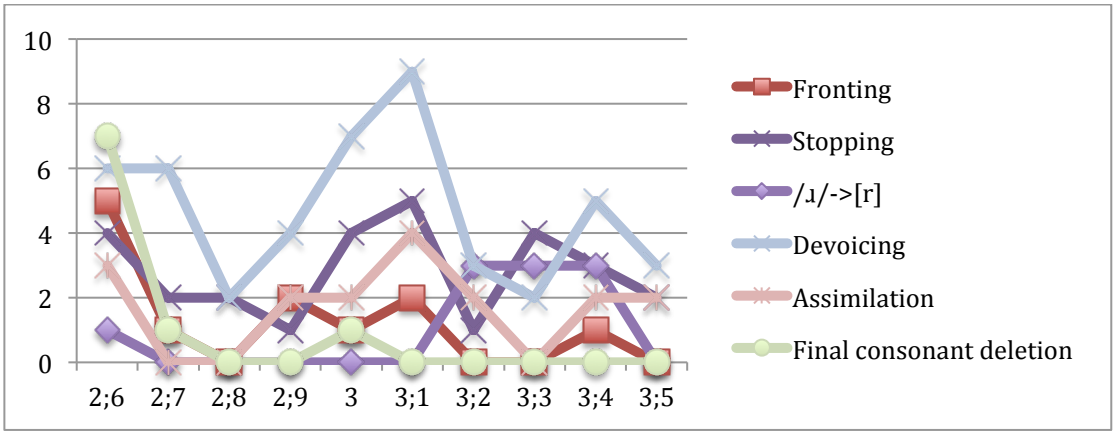
Graph 5-4 illustrates the frequency of error patterns in English. Devoicing was found to be the most frequently occurring error pattern by far in the participant's English speech production, accounting for 20% of total error patterns. Stopping scored 9% while cluster reduction, assimilation and middle consonant deletion frequency of occurrence were analogous, scoring 6% each of total errors. Moreover, final consonant deletion had 5% frequency percentage whereas the rest of the error patterns identified scored below 5% of total error patterns throughout the data collection period.



Graph 5-4: Overall error patterns in English language

2. Frequency analysis

Graph 5-5 demonstrates error pattern frequency of occurrence over the data collection period. All error patterns show a noticeable decline over time.



Graph 5-5: Longitudinal frequency analysis of error patterns in English

5.1.2 Arabic

5.1.2.1 Percentage consonant correct (PCC)

Table 5-5 illustrates the results of the participant's Arabic PCC. There was a 24.8% increase of SF's accuracy of production during the one-year period.

PCC	Arabic
2;6	64%
3;5	88.8%
Average	76.4%

Table 5-5: Arabic PCC

5.1.2.2 Phonemic repertoire

1. Plosives

At the end of data collection, all Arabic plosive consonants were acquired. While phonemes /b/, /t/ and /k/ were mastered early, /d/, /g/ and /q/ acquisition went through period of fluctuation and reached acquisition level at the end. The most noticeable substation pattern was the devoicing of /g/ into its counterpart [k] in different words and tokens from 2;7 and throughout the data collection period. Moreover, /q/ was realized as [g] for most of its production.

Age	b	sub	t	d	sub	k	sub	g	sub	q	sub
2;6	86	[f]	100	75	[t], [b], [tˁ]	100		100	[1]	100	[1]
2;7	100		100	70	[dʒ], [t]	100		100	[1]	0	[ʔ]1
2;8	83	[p]	100	100		60	[p], [t]	0	[k]1	100	[1]
2;9	100		100	100		100		100	[1]	n/d	
3	91	[f]	100	92	[s]	100		50	[k]	0	[g]1
3;1	82	[f]	100	100		100		50	[k]	33	[t], [g]
3;2	90	[m]	100	87	[t]	100		75	[t]	0	[g]
3;3	100		100	100		100		80	[k]	25	[g], [k]
3;4	95	[f]	100	100		100		80	[q]	60	[χ], [g]
3;5	92	[m]	100	88	[t]	100		88	[d]	75	[g]

Table 5-6: Arabic plosive consonants acquisition and substitution patterns

2. Fricatives

Labiodental and post alveolar consonants

The phonemes /f/ and /ʃ/ were mastered at the end of data collection period. The labiodental /f/ was acquired and stabilized early, with some marginal slips at 3;4. On the other hand, the post-alveolar /ʃ/ scored 100% at the beginning of data collection then went through periods of fluctuation from 2;8 until reaching stabilization at 3;4 and was occasionally substituted by the alveolar [s].

Interdentals /θ/, /ð/

Interdentals acquisition pattern seemed to rise steadily despite some marginal dips throughout the data collection period. Moreover, the phoneme /θ/ seemed to have a higher accuracy percentage and seemed to stabilize at the end of the data collection period; however, there were only two occurrences of the target value, so it may not reflect real mastery or stabilization. As for its voiced counterpart, its production alternated with the voiced alveolar [d] while /θ/ alternated with the voiceless alveolar [t] in which both underwent the phonological process of stopping. It is important to point out that there were not enough occurrences for either phoneme to accurately evaluate their development and stabilization.

Alveolar /s/, /z/

In comparison, the voiceless /s/ had a higher accuracy score throughout the data collection period than its voiced counterpart /z/. It seemed that the acquisition rate was going through a steady rise right until 3;2, when both reached 100%

attainment score only to fall the next month and then rise and fall again at the end of data collection. The acquisition of these phonemes did not stabilize at the end of data collection, with a noticeable decrease as indicated in the table. As for substation pattern, at 3;1 years the phoneme /s/ appeared to alternate predominately with the voiceless interdental [θ]. As for its voiced counterpart, it seemed to occur in variation with different sounds; however, it appeared to be devoiced into its counterpart frequently.

Uvular /χ/,/ʁ/

The uvular consonant acquisition rate went through episodes of steady rise and sharp falls throughout the year. The accuracy percentage was higher for the voiceless phoneme /χ/ than its voiced counterpart /ʁ/; at the beginning of data collection, they scored 37% and 0% respectively. At the end of the data collection period, the phoneme /χ/ reached acquisition rate while its voiced counterpart did not seem to reach its target value. However, there were not enough opportunities to judge the rate of acquisition for /ʁ/ because the participant avoided producing words containing that segment. Moreover, in terms of substation pattern, /χ/ seemed to be in alternation with [h] most of the time.

In terms of fricative acquisition pattern, it is noticeable that the voiceless fricatives had higher accuracy and attainment rate than their voiced counterparts.

Age	f	sub	θ	sub	ð	sub	s	sub	z	sub	ʃ	sub	χ	Sub	ʁ	sub
2;6	100		60	[t]	0	[d]	82	[ʔ], [t]	50	[s]	100		37	[ʔ], [h]	0	[ʔ], [d], [h]
2;7	100		50	[t]	0	[d]1	100		50	[s]	100		66	[h]	33	[χ], [l]
2;8	86	[w]	80	[t]	0	[d]	90	[ʃ]	0	[s]1	73	[s]	100	(2)	100	[1]
2;9	100		60	[f], [d]	n/d		88	[χ]	50	[s], [f]	100		25	[h], [k], [s]	0	[j], [s]
3	80	[b]	n/d		50	[d]	100		50	[s]	62	[s], [t]	100		0	[ʔ], [g]

3;1	100		50	[t]1	100	(2)	92	[θ]	60	[r], [s]	77	[s]	66	[h]	100	[1]
3;2	100		n/d		100	(2)	100		100	(2)	80	[χ]	50	[h]	0	[ʔ], [s]
3;3	100		66	[t]	66	[d]	88	[θ]	50	[s], [ð]	90	[s]	75	[h]	0	[ʔ]1
3;4	93	[ʃ]	100	(2)	66	[d]	95	[θ]	100		100		80	[h]	50	[j]1
3;5	100		100	(2)	100	[1]	87	[θ], [t]	33	[s], [k], [d], [t]	100		75	[ħ]	0	[j]1

Table 5-7: Arabic fricative consonants acquisition and substitution patterns

3. Pharyngeal and emphatic consonants

Age	ħ	sub	ʕ	sub	tˤ	sub	sˤ	sub	ðˤ	sub	dˤ	sub	lˤ	sub
2;6	62	[h], [ʔ]	43	[ʔ], [j]	50	[d]1	14	[s]	n/d		0	[d], [tˤ]	0	[l]
2;7	37	[h]	57	[ʔ]	50	[q], [t]	50	[t]1	0	[tˤ]1	0	[d]	n/d	
2;8	55	[h], [χ]	54	[ʔ]	0	[d], [t]	0	[s]1	n/d		0	[d]1	n/d	
2;9	67	[h]	60	[ʔ]	0	[d], [t]	n/d		n/d		n/d		n/d	
3	100		62	[ʔ]	44	[k], [d], [t]	55	[s]	n/d		0	[d]	n/d	
3;1	83	[h]	62	[ʔ]	36	[t], [d]	27	[s], [θ]	0	[ð]1	50	[t]1	n/d	
3;2	77	[h]	50	[ʔ]	50	[t], [d], [j]	43	[s]	0	[ð]1	66	[d]	100	[1]
3;3	89	[h]	86	[ʔ]	50	[t], [g]	0	[s]2	50	[d]1	50	[ʔ]1	n/d	
3;4	93	[h]	79	[ʔ], [ħ]	86	[q]	91	[s]	0	[tˤ], [h]	100		100	[1]
3;5	94	[h]	82	[ʔ], [h]	100		57	[s]	50	[tˤ]1	100		n/d	

Table 5-8: Arabic pharyngeal and emphatic consonants acquisition and substitution patterns

SF's acquisition pattern of the pharyngeal and emphatic consonants could be characterized as developmental. The phonemes / ħ/, /ʕ/, / tˤ/ and / dˤ/ were acquired at the end of the data collection period. The predominant error patterns deployed by the participant were de-pharyngealization and de-emphasis.

4. Nasals /m/, /n/, approximants /r/, /l/, /j/ and affricate /dʒ/

Nasal and affricate consonants

SF production demonstrated early stabilization and mastery of nasal consonants. Some discrepancy in the age of acquisition across nasal consonants was observed in which the phoneme /m/ was acquired earlier than /n/. In addition, /n/'s production started to stabilize around the age of three, while the phoneme /m/ was already stable at the beginning of data collection. In rare occasions, the sound /m/ was substituted by [b]; during these months, the participant suffered from a cold as observed in her English production.

Throughout the period of data collection, the acquisition of the affricate consonant /dʒ/ fluctuated before stabilizing during the last two months. Its accuracy rate was 40% at the beginning of data collection, only to reach a mastery level of 100% the following months. However, at three years, its accuracy had dramatically fallen by almost 40% then started its gradual attainment. For the substitution pattern, it mostly went under deaffrication process and realized as [d].

Tap or flap

There is a fluctuation in SF's acquisition of her alveolar tap /r/ at 2;6 until 3;1; her accuracy of production dropped from customary level at 2;7 to 0% at 2;9 and 3, only to reach mastery level at 3;2 and dropped again to acquisition level at the last month of data collection. It was substituted frequently by the approximant alveolar [ɹ]

(e.g. [sejjaɹah] car, [ʃəʕaɹ] hair, [ɹəbbi] god) and by the lateral approximant alveolar [l] a few times (e.g. [ʔəmalə] moon, [ʔəʃalah] ten, [laħ] gone).

Lateral approximant /l/

The phone-segment /l/ was acquired and mastered early. Moreover, it was realized as [l̪], [ɬ] and [ɹ] few times.

Age	m	sub	n	sub	r	sub	l	sub	j	sub	w	sub	dʒ	sub
2;6	100		93	[j]	43	[n], [l], [ʃ], [ɹ]	93	[d]	100		100		40	[d], [θ], [ʔ]
2;7	100		92	[l]	50	[j]1	81	[t], [l̪]	100		100		100	
2;8	94	[b]	83	[j], [d]	10	[l], [j], [b], [ɹ]	83	[l̪], [ɬ]	80	[n]	90	[h]	100	
2;9	100		75	[j], [t]	0	[b], [ɹ], [l], [k]	88	[l̪]	100		100		0	[ʒ]1
3	93	[b]	100		0	[d], [ɹ]	83	[i], [ɹ]	100		100		62	[d]
3;1	100		100		26	[ɹ]	90	[l̪]	100		83	[r]	66	[d]
3;2	100		100		100		100		100		100		83	[d]
3;3	100		100		100		90	[n]	88	[ʔ]	100		71	[j], [tʃ]
3;4	94	[n]	95	[m]	100		100		100		100		100	
3;5	100		100		85	[w], [t], [ɹ]	92	[ɬ], [ʔ]	100		100		100	

Table 5-9: Arabic nasal, tap/flap, approximant and affricate consonants acquisition and substitution patterns

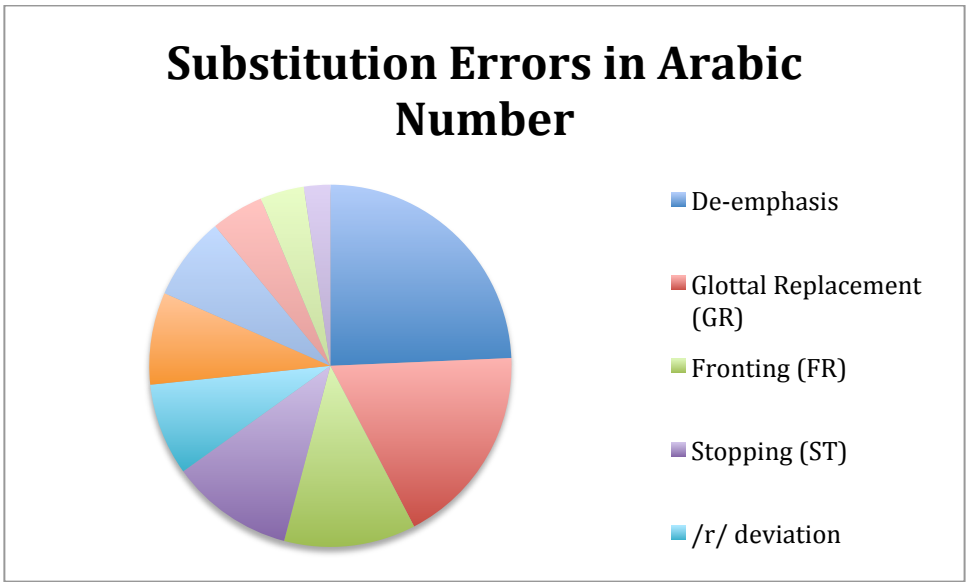
5.1.2.3 Error analysis

1. Type analysis

1.1 Substitution errors

Graph 5-6 demonstrates substitution error pattern frequency of occurrence in SF's Arabic language speech production. The most frequently occurring error patterns were de-emphasis and glottal replacement, accounting for 24% and 18% of total substitution errors in Arabic language respectively. Fronting and stopping reached

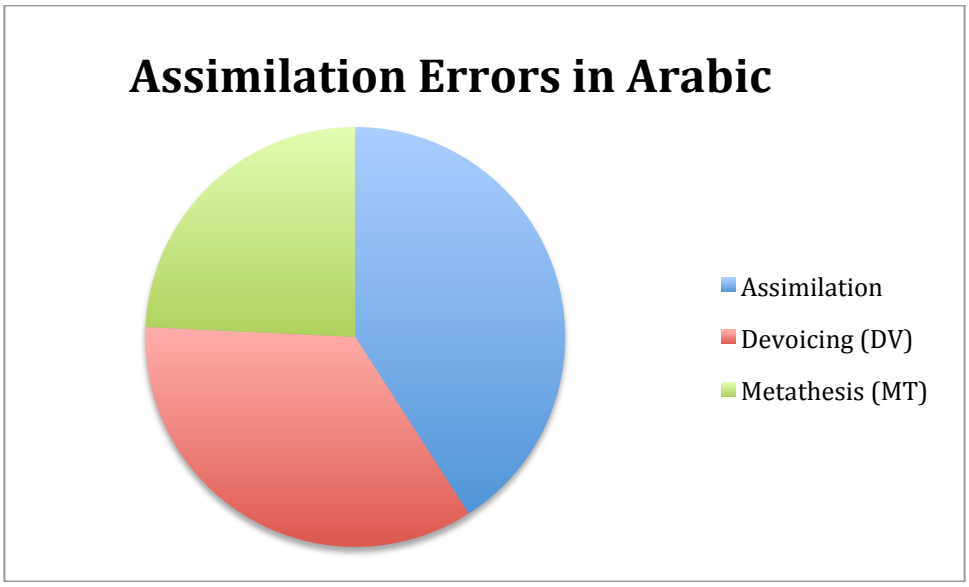
similar values of 12% and 11% respectively. /r/ deviation, backing, de-pharyngealization and lateralization frequency scores reached below 10%, while deaffrication and spirantization scores were below 5%.



Graph 5-6: Substitution error patterns in Arabic

1.2 Assimilation errors

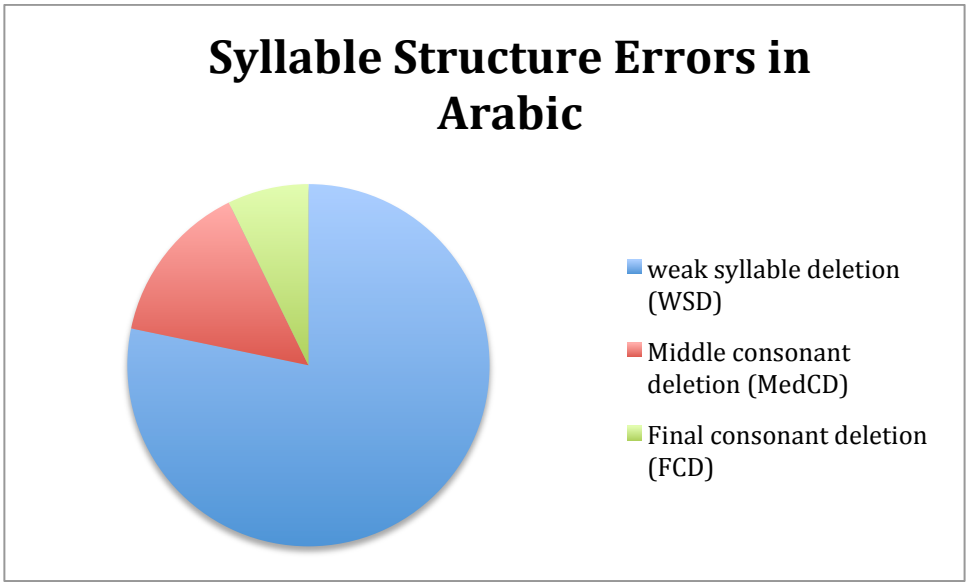
Three types of assimilation errors were identified in the participant's production. The most frequently occurring error pattern was assimilation, counting for 41%. Devoicing frequency reached 35%, while metathesis error pattern was the least frequent, scoring under 25% of total assimilation errors.



Graph 5-7: Assimilation error patterns in Arabic

1.3 Syllable structure errors

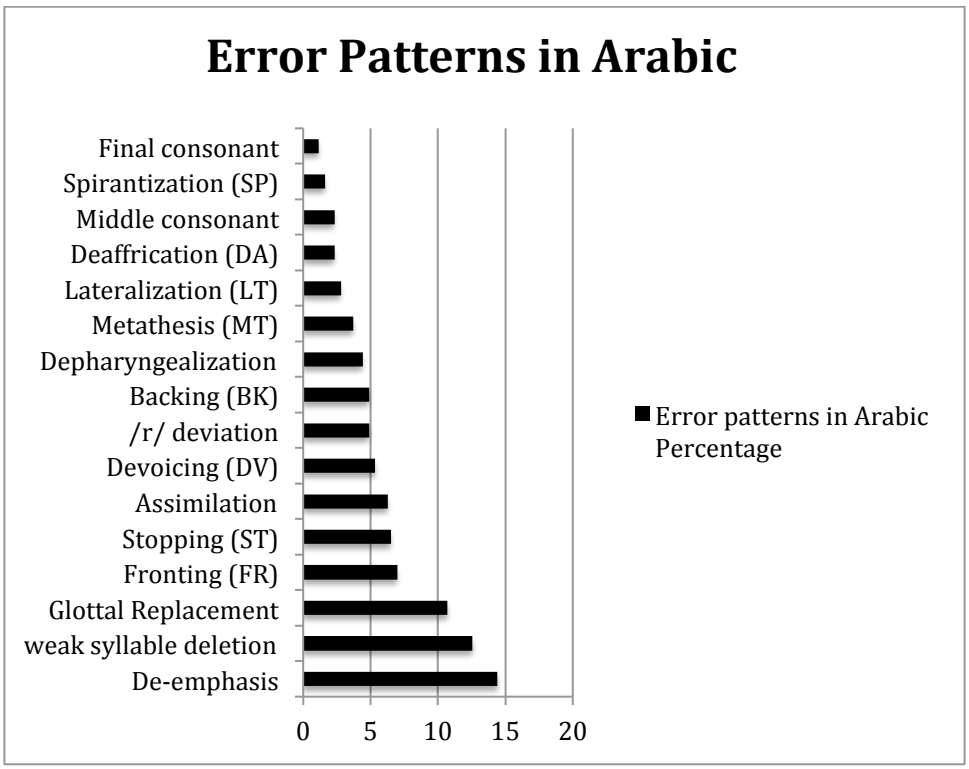
Graph 5-8 demonstrates the frequency of syllable structure error patterns in the participant's Arabic production. Weak syllable deletion was the most frequent error pattern, scoring 78% of total syllable structure errors. Middle and final consonant deletion frequency scores were 14% and 7% respectively.



Graph 5-8: Syllable structure error patterns in Arabic

1.4 Overall error patterns in Arabic

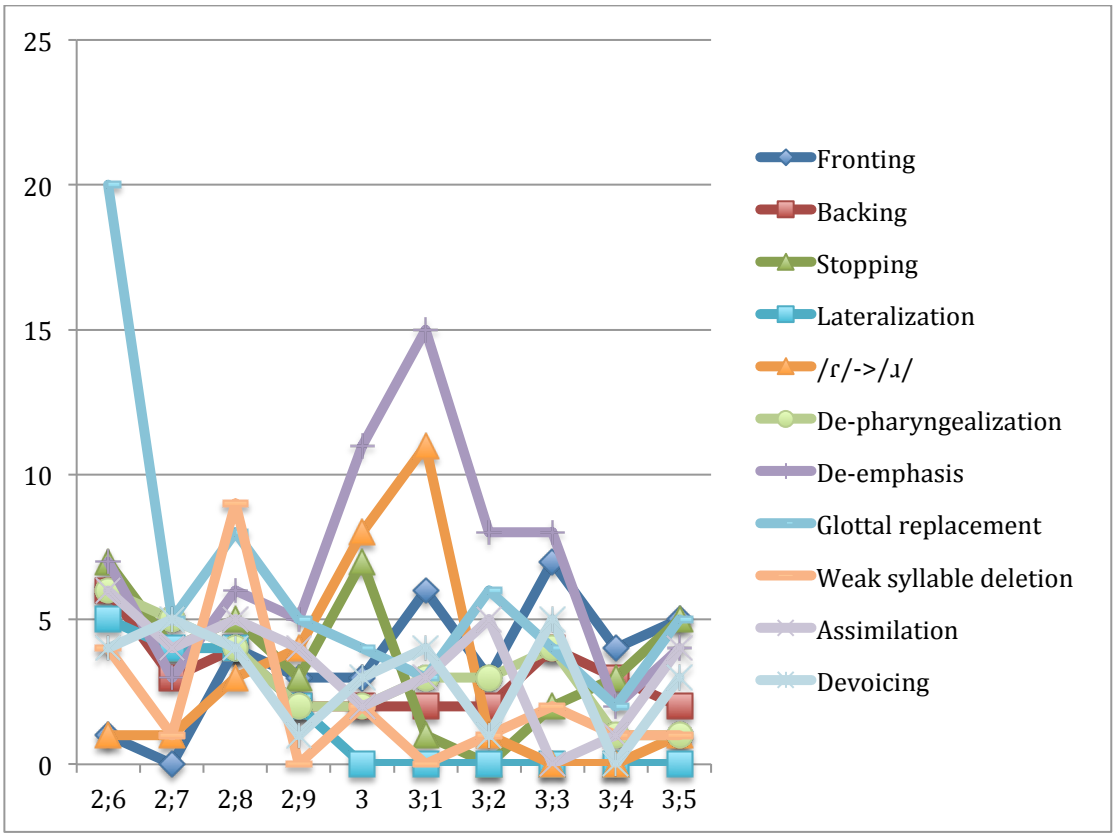
De-emphasis, weak syllable deletion, and glottal replacement were the most frequently occurring error patterns identified in the participant's Arabic production, scoring more than 10% as demonstrated in Graph 5-9. Stopping, assimilation, and devoicing reached comparable values of around 6% each. The rest of the error patterns' frequencies of occurrence were under 5%.



Graph 5-9: Overall error patterns in Arabic language

2. Frequency analysis

Graph 5-10 demonstrates error pattern frequency over the data collection period. Most occurrences of error patterns showed an overall decline, except for fronting error pattern, which demonstrated a steady increase during this period.



Graph 5-10: Longitudinal frequency analysis of error patterns in Arabic

5.1.3 Comparison between English and Arabic phonological acquisition

5.1.3.1 Percentage Consonant Correct (PCC)

Table 5-10 illustrates the PCC across languages. At the beginning of data collection, her score in English was 8.2% higher. However, this margin had decreased to 2.4% at the end of data collection period.

PCC	English	Arabic
First month	72.2%	64%
Last month	91.2%	88.8%
Average	81.7%	76.4%

Table 5-10: English and Arabic PCC

5.1.3.2 Phonemic repertoire

SF	English			Arabic		
Age	Mastery production (>90%)	Acquisition production (75-89%)	Customary production (50-74%)	Mastery production (>90%)	Acquisition production (75-89%)	Customary production (50-74%)
2;6	/b/, /k/, /m/, /n/, /ŋ/, /dʒ/, /tʃ/, /l/	/p/, /t/, /d/, /s/, /j/,	/g/, /f/	/t/, /g/, /m/, /n/, /f/, /ʔ/, /w/, /j/, /h/, /k/	/b/, /s/, /l/	/θ/, /z/
2;7	/b/, /t/, /k/, /s/, /dʒ/, /tʃ/, /l/	/d/, /ɹ/,	/p/, /g/, /f/, /v/	/g/, /s/,/b/, /k/, /f/, /dʒ/	/b/, /l/	/θ/, /z/, /χ/
2;8	/p/, /b/, /k/, /f/,/s/, /g/, /dʒ/,	/d/, /ɹ/, /v/, /l/		/g/, /s/,/b/, /dʒ/	/l/, /f/	/θ/, /z/, /χ/, /k/
2;9	/p/, /b/, /k/,/s/, /dʒ/,	/d/, /ɹ/, /l/	/g/, /ʃ/, /v/	/k/, /g/, /b/, /f/	/l/, /s/	/θ/, /z/, /χ/
3	/p/,/b/, /s/, /dʒ/,	/d/, /k/, /z/, /ɹ/, /f/, /l/	/g/, /ð/, /v/	/s/, /ʃ/,/b/	/ħ/, /l/, /f/	/g/, /θ/, /ð/, /z/, /χ/, /dʒ/
3;1	/p/, /f/, /v/, /dʒ/, /l/	/d/, /b/, /k/, /s/, /z/, /ɹ/, /ʃ/,	/g/, /θ/, /ð/, /v/	/s/, /l/, /f/	/ʃ/, /ħ/, /b/	/g/, /θ/, /z/, /χ/, /dʒ/
3;2	/p/, /d/, /f/, /z/, /dʒ/,	/b/, /k/,	/g/, /ð/, /s/,	/b/, /s/, /ɾ/,	/g/, /ʃ/, /ħ/, /dʒ/	/tˁ/, /dˁ/, /θ/, /z/, /χ/
3;3	/p/, /d/, /k/, /s/, /g/, /dʒ/,	/b/, /z/, /f/	/ð/, /v/	/d/, /ʃ/, /ɾ/,	/s/, /χ/, /ħ/, /ʕ/	/tˁ/, /dˁ/, /θ/, /z/, /dʒ/
3;4	/p/, /d/, /k/, /ɹ/, /dʒ/,	/g/, /f/, /s/	/g/, /ð/, /v/	/d/, /dˁ/, /θ/, /s/, /ɾ/, /dʒ/, /ħ/	/tˁ/, /χ/, /ʕ/	
3;5	/b/, /f/, /s/, /ɹ/	/p/, /d/, /k/,	/z/, /dʒ/	/tˁ/, /dʒ/,	/q/, /s/, /d/, /χ/, /ʕ/, /ɾ/,	

Table 5-11: English and Arabic phonemic inventories
Note: Highlight indicates fluctuation

1. Plosives

The participant achieved close levels of attainment across her shared plosives. Phonemes /b/ and /d/ fluctuated from mastery to acquisition levels in both languages, and only /b/ was mastered at the end of data collection in English and around 3;2 in Arabic. On the other hand, /k/ was mastered across languages early, but in English, it fluctuated between mastery and acquisition levels. Moreover, phoneme /g/'s

acquisition pattern demonstrated great variability in English and Arabic; nonetheless, it reached acquisition level earlier in Arabic than in English.

In terms of substitutions, comparable patterns were found across the two languages in which phonemes /d/ and /g/ were produced in alternation with [t] and [k] respectively. At the end of data collection, the Arabic /t/ and /k/ production and the English /b/ and /t/ had stabilized.

2. Fricatives

Table 5-11 illustrates the participant's phonemic inventory across English and Arabic. Fricative acquisition pattern appears to be comparable across languages with few exceptions. For example, phoneme /f/ and /s/ fluctuated between mastery and acquisition levels and were mastered at the end of data collection in English while only /f/ was mastered in Arabic. Moreover, phoneme /z/'s acquisition level was higher in English than Arabic, where it reached acquisition level for English only to regress to customary production at the end of data collection period. For the interdentals, they did not extend beyond customary level in English, while phoneme /θ/ was mastered by the end of data collection in Arabic.

Regarding substation patterns, comparable patterns were found in the production of interdentals and voiced alveolar /z/. On the other hand, voiceless alveolar /s/ and postalveolar /ʃ/ were realized differently across languages. At the end of data collection, the phonemes /f/ and /ʃ/ were stabilized in both languages, while the English phoneme /s/ was near stabilization.

3. /ɾ/ and /ɹ/

SF's acquisition pattern of English /ɹ/ was more advanced and stable than her Arabic /r/, though comparable at times. At the end of data collection, the English /ɹ/ reached mastery level, while the Arabic /r/ had regressed to acquisition level.

Substitution patterns were similar in terms of alternating with the phoneme [l]. More importantly, the interaction between her phonological systems was bidirectional in the sense that English and Arabic phonological systems influenced her production in both languages. However, this conclusion should be approached with cautious since the dialectical variety of the phoneme /ɹ/ in Scottish is tap or flap /ɾ/, as discussed earlier.

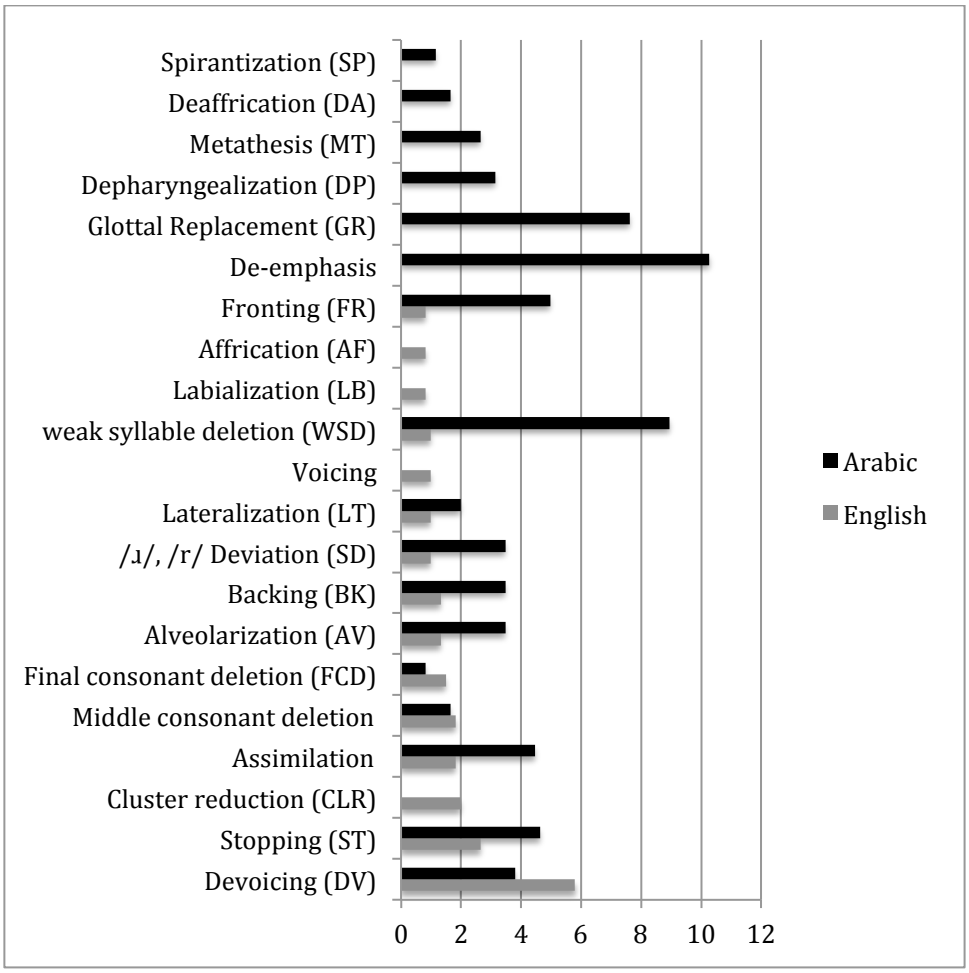
4. Nasal and affricate consonants

Nasal consonants were acquired and stabilized early in both languages. Their acquisition was comparable across languages, even though her English nasal accuracy levels were marginally higher. In terms of SF's acquisition of the affricate consonant /dʒ/, it seemed to be mastered and stabilized at the beginning in English except for the last month of data collection, while in Arabic its production fluctuated and was mastered around 3;4. Moreover, at the beginning of data collection the participant's English affricate appeared to be stabilized and reached its target value, while in Arabic its production alternated with [d] as it went under deaffrication process.

5.1.3.3 Error analysis

1. Type

Graph 5-11 illustrates the frequency of error patterns in the participant's languages. Overall, the percentage of Arabic errors dramatically exceeded English errors. Some error types were identified across languages, and some error patterns were language specific. For example, devoicing, stopping, assimilation, middle and final consonant deletion, alveolarization, backing, /ɹ/, /r/ deviation, lateralization, weak syllable deletion and fronting were common between English and Arabic. These error patterns had a higher frequency of occurrence percentage in Arabic than English except for devoicing, middle and final consonant deletion. Cluster reduction, voicing, labialization, and affrication were identified in the participant's production of English only. Others like de-emphasis, glottal replacement, depharyngealization, metathesis, deaffrication and spirantization patterns were observed in the participant's Arabic production exclusively.



Graph 5-11: Comparison between English and Arabic error patterns

2. Frequency analysis

All error patterns across languages demonstrated a steady decrease over time except for fronting error pattern in Arabic language.

5.2 Summary and discussion

5.2.1 Summary

5.2.1.1 Segmental acquisition

Transfer

Transfer between the participant's segmental phonological systems was evident in her production of the tap alveolar /ɾ/ in Arabic and the approximant alveolar /ɹ/ in English. That transfer was bidirectional, affecting both her English and Arabic production. The phoneme /ɹ/ was realized as /ɾ/ for 7% of its total production. Nonetheless, it was stabilized at the last month of data collection. As for the production of Arabic phoneme /ɾ/, 26% of its total production was substituted with the English approximant /ɹ/. After participant had reached 3;2 years, her production of Arabic /ɾ/ improved and the percentage of bi-directional transfer decreased. This decrease is a clear indication of an increase in language differentiation. In addition, the percentage of transfer in the production of Arabic /ɾ/ seemed to be higher by triple than in English. Moreover, the data demonstrated some interesting trends during the period when the participant was 3;2 through 3;4. Her accuracy of Arabic production reached 100%, but her English production was affected, and the English /ɹ/ was realized as /ɾ/ occasionally during this period as well as once at the beginning of data collection. At the last month of data collection, the participant production's accuracy had decreased to 85% and was realized as English /ɹ/ occasionally. Previously, it was

indicated that this bi-directionality of transfer needed to be approached with caution, since the dialectical variety of Scottish English /ɹ/ is also tap or flap /ɾ/. However, if we assume that the participant's production of the tap or flap /ɾ/ is within the Scottish English variety and not caused by cross-linguistic interaction of the Arabic tap or flap /ɾ/, then its absence from her English production after she turned 3;1 years cannot be accounted for. The stabilization of the phoneme /r/ was evident in both languages over time, which supports the assumption that this interaction is developmental. Longitudinally, language differentiation was increased and she reached the target production of these phonemes.

Some examples are:

a. Arabic

[sejjaɹah] car

[ʃəʕaɪ] hair

b. English

[kærət] carrot

[pʌtərflaɪ] butterfly

Another phoneme that exhibited a marginal degree of transfer from English to Arabic was the approximant /l/. English phoneme /l/ as well as the dark /ɬ/ was acquired and stabilized early during the data collection period. As for Arabic /l/, its production accuracy was also high, but its production exhibited some rare variability.

Arabic /l/ was realized on some occasions as dark [ɬ] (found only in two lexical items) and at times as a dental [l̪] (found in three lexical items) of total production. However, it was mastered at 3;1 years.

Acceleration and deceleration

SF appeared to have good proficiency in both of her languages even though she had a higher PCC in English than Arabic as a result of attending an English nursery for full time. The segmental analysis showed that her early-mastered English sounds consisted of nasals /m, n, ŋ/, stop /t/ and fricative /f/. Other segments such as /p, b, k, s/ seemed to fluctuate between mastery and acquisition levels at this period. Compared to McIntosh and Dodd's (2008) study, the participant's acquisition appeared to be decelarated in terms of the stop phonemes /p, b, d, k, g/, which were mastered by English children between 2;0 and 3;0 and were classified as early sounds. In addition, phonemes /s/ and /b/ stabilized at 3;3 and 3;5 respectively. The phoneme /ɹ/ was mastered by the participant at 3;4 years; its mastery is considered accelerated since it is a late-acquired sound by English-speaking children.

For her Arabic acquisition, the participant's early mastered sounds consisted of /t, k, ʔ/ and /m, n/. The phoneme /g/ acquisition fluctuated between mastery and acquisition level during this period. In comparison to Alqattan’s (2015) results, the participant’s acquisition was accelerated for /t, ʔ, n/ at the early stage. In addition, the

participant mastered the following segments between 3;1 and 3;6: /b/, /d/, /s/, /ɾ/, /f/, /χ/, /ħ/, /ʤ/, /tˤ/, /dˤ/, /l/, /w/ and /j/. Her acquisition appeared to be accelerated for the following segments: /χ/, /ħ/, /ʤ/, /tˤ/ and /dˤ/, compared to Arabic children monolinguals. Moreover, the tap /ɾ/ seemed to be mastered between 3;2 and 3;4, but at 3;5 its accuracy of production decreased to under 90%.

To summarise, her English inventory exhibited some elements of acceleration and delay, while her Arabic inventory was accelerated compared to Arabic monolingual children.

5.1.2.2 Error analysis

Table 5-12 illustrates error patterns reported in SF's production during the data collection period across her two languages. Some of these errors are described as language-specific errors, while others occurred cross-linguistically.

Age	2;6 -2;11		3;0- 3;5	
Language	E	A	E	A
1. Substitution error patterns				
Fronting	SF			SF
Backing		SF		
Dentalization				
Stopping				
Gliding				
De-affrication				
De-emphasis		SF		SF
Lateralization of /r/		SF		
/ɾ/ ->/ɹ/		SF		SF
/ɹ/->/ɾ/			SF	
Glottalization		SF		SF

2. Assimilation				
De-voicing	SF	SF	SF	SF
Voicing				
Assimilation				
3. Syllable error patterns				
Final consonant deletion	SF			
Cluster reduction	SF			
Weak syllable deletion		SF		

Table 5-12: SF's error patterns across English and Arabic speaking children

a. Language specific error pattern

De-emphasis error pattern was among the most frequently occurring error pattern reported in SF's speech sample. The peak of this process was observed from 2;6 through 2;7 years, in which 66% of the target emphatics underwent de-emphasis. At the last month of data collection, this process was reduced dramatically to 19% of target emphatics. This decrease established a reduction in frequency correlated with age and shows that the participant was able to acquire the Arabic emphatics over time. A relevant study by Alqattan (2015) showed the same error pattern decreased in frequency from 49% to 11% by Arabic monolinguals between the age groups of 2;4-2;7 and 3;4-3;7 respectively. Even though Arabic monolingual children seemed to acquire the emphatics at a faster rate than SF, that difference is relatively small. The acquisition of emphatics seems to show a positive correlation with age by Arabic monolingual speakers and the participant, thus reflecting monolingual norms.

Glottal replacement error pattern was found to be among the most frequently occurring error patterns used by the participant. The production of this error demonstrated a steady decrease in frequency over time, from 32% at the beginning of data collection to 8% at 3;5. However, this error pattern is considered among the rare error patterns found in the speech data of Arabic monolingual children, and its

frequency reached 1% of total errors by children aged 1;4- 3;7 (Alqattan, 2015). However, it was reported as an age-appropriate error in other studies.

B. Cross-linguistic error patterns

Stopping error pattern was observed in the participant's production across English and Arabic. It was rated among the highest frequently occurring error patterns in her English production, while it scored as a mid-high error in Arabic. It is important to point out that, even though it had a higher frequency in English than in Arabic, the number of occurrences, in fact, is higher in Arabic due to the higher number of errors produced in the participant's Arabic compared to English production. This error pattern occurrence decreased in frequency over time, with occasional fluctuation. In comparison to monolingual norms, the participant acquisition appears typical.

Lateralization was among the least frequently occurring error patterns reported in the speech of SF during the data collection period. The peak of the production of this error was reported at 2;6-2;9; after 3, no reported lateralization pattern was found. Instead, the participant used the approximant alveolar English /ɹ/ to substitute the tap alveolar Arabic /ɾ/. As lateralization error pattern decreased, /ɾ/ deviation error pattern increased. Nonetheless, after the participant turned 3;2, a sharp decrease in the production of this error was observed and an increase of language differentiation was more evident in the production of this phoneme. As for her English production, a few rare instances of lateralization and /ɹ/ deviation error patterns were reported, while gliding error was not observed. Even though her Arabic production was more affected by these errors, it appeared in her English production episodically, which could

support bi-directionality of interaction. Compared to the production of Arabic monolingual children, it is concluded that the participant seemed to follow the norms of monolinguals until she was three years old. After three, monolinguals continued to use lateralization error patterns, while the participant seemed to have acquired the English /ɹ/ and used it as a substitute for the Arabic /ɾ/ occasionally. On the other hand, the production of her English /ɹ/ did not follow the monolinguals norms in which they deployed gliding process for the production of /ɹ/.

Devoicing error pattern was found to be among the most frequently occurring error patterns in SF's English production. This error pattern was also observed in her Arabic production but with a lesser frequency. Longitudinally, its production demonstrated a subtle decrease over the period of her acquisition associated with periods of fluctuation across her languages. It was observed that the acquisition of this error pattern by the participant had an element of deceleration in comparison to English monolingual children. English monolinguals reported low frequency of devoicing error pattern. On the other hand, Arabic monolinguals seem to produce this error frequently under the age of three, which demonstrates that the participant's acquisition followed monolingual norms. Nonetheless, for children over three years, this error was classified as a rare error by Arabic monolinguals while it still occurred in the participant's speech. In that case, an aspect of deceleration is observed after three years in regards to the participant's acquisition of Arabic.

Deaffrication error pattern was reported in low frequencies across her English and Arabic production. In comparison to monolingual norms across English and Arabic languages, the participant's acquisition demonstrated an aspect of acceleration as far as the production of affricate consonants are concerned.

Assimilation error pattern across the participant's language show similar values of occasional frequencies in comparison to the total number of errors in each language. However, parallel comparison revealed that this error pattern had a higher number of occurrences in her Arabic production. This increase is foreseeable since the total number of errors reported in her Arabic exceeded that in her English production. In addition, the rate of this pattern production demonstrated a marginal decline associated with periods of fluctuation across her languages. Overall, the participant followed similar patterns of English monolinguals. As for her Arabic, this error pattern was not reported by Arabic studies. Therefore, we can assume that the participant followed monolingual norms since her production of that error is rare.

Cluster reduction error pattern was observed only in SF's English production with occasional frequency. This error seemed to affect her speech production between 2;6 through 2;9, after which its occurrence was very rare. Regarding her acquisition patterns compared to English monolinguals, it is clear that the participant followed the norms under three years old. However, after three years her acquisition seemed to be accelerated. In addition, since this error did not occur in her Arabic production and was found to be an age-appropriate under three in the speech of Arabic monolinguals, it is safe to conclude that there was evidence of acceleration in relation to this error pattern.

The occurrence of weak syllable deletion error pattern exhibited great divergence in the acquisition patterns of English and Arabic by the participant. This pattern was reported as one of the most frequently occurring error patterns in her Arabic production, while it was noted to occur at low frequencies in her English production. In comparison to monolingual trends, the participant acquisition pattern demonstrates an aspect of acceleration for her English. As for her Arabic, the

participant exhibited monolingual trends before the age of three. After she turned three years old, weak syllable deletion frequency of occurrence was rare, while it was reported in the production of Arabic monolinguals.

5.2.2 Discussion

The findings reveal that SF's acquisition demonstrated aspects of convergence and divergence of monolinguals acquisition. Some elements of English phonemic acquisition and error patterns exhibited trends toward acceleration and delay as well as a normal rate of acquisition compared to monolinguals. This aspect is also pertinent to her Arabic acquisition with an exception of her segmental inventory, which proved to be more advanced than Arabic monolinguals.

Three criteria have been selected to measure the possible manifestation of interaction. First, the cross-linguistic interaction was observed to affect the production of phonemes /ɾ/, /ɹ/ and /l/. While the interaction of the production of English and Arabic /r/ was systematic and bi-directional, the application of English /l/ allophonic rule to few Arabic lexical items was episodic and rare. The amount of language exposure appeared to have a direct influence on the directionality of interaction. Moreover, it is important to point out that bi-directional transfer occurred at two different periods, though overlapped at times. For instance, the peak of /r/ deviation error pattern reported in her Arabic production was between 2;6 and 3;1, while the transfer of Arabic /r/ into English was observed between 3;2 and 3;4. The frequency of this transfer was higher in Arabic than English. Nonetheless, at the end of data collection, aspects of phonological interaction decreased while language differentiation increased.

Other aspects of cross-linguistic interaction were acceleration and deceleration. While some aspects of acceleration were observed in the participant's phonemic acquisition and error patterns as compared to monolinguals across languages, total deceleration of the rate of acquisition was not observed. Moreover, the accelerated elements reported were not for the shared segments across her languages. In this case, aspects of acceleration were found in the participant's acquisition of some emphatics and pharyngeal consonants that were specific to Arabic. A similar case is reported in a study by Grech and Dodd (2008) in which they concluded that the phonological accuracy of bilingual children exposed to Maltese and English was higher than that of their monolingual Maltese peers and other English monolingual children. This result was attributed to the positive effect of bilingualism, in which it found to stimulate learning and higher discrimination across the bilingual children's phonological systems, resulting in accelerated acquisition in comparison to their age-matched monolingual peers.

6 Case study (AM)

6.1 Results

This section is a detailed account of AM's consonant acquisition throughout the data collection period. The results are divided into three different sections: (1) English data, (2) Arabic data and (3) comparison between English and Arabic phonological development.

6.1.1 English data

Segmental production of the participant was examined for matches and substitutions. Three measures were considered: PCC, phonemic repertoire and error analysis.

6.1.1.1 Percentage consonant correct (PCC)

The participant's PCC was calculated at two different points: when the participant was 2;6 and at the last month of data collection period, when he reached 3;4 years old. The average percentage was computed by adding the PCC percentages of the first month and last month of data collection and divided by two. The results are presented below:

PCC	English
2;6	69%
3;4	76.7%
Average	72.85%

Table 6-1: English PCC

6.1.1.2 Phonemic repertoire

1. Plosives

At the end of data collection, AM had mastered all the English plosives. His acquisition pattern appeared to be developmental, and it is apparent that his speech production accelerated after he turned 2;10 years old as illustrated by Table 6-2. It is worthwhile to mention some of the interesting substitution patterns of the English plosives observed throughout the data collection period, two patterns were observed: devoicing and the use of favourite sound.

It appeared that some of AM's alternations were realized as their devoiced counterparts. For example, the phoneme /g/ alternated with the sound [k] throughout the data collection period, and the phoneme /d/ was substituted on several accounts with its voiceless counterpart [t]. In addition, the phoneme /p/ was realized as its devoiced counterpart [b] throughout the data collection period. At 2;8,9 and 3;2, the phoneme /p/ was realized exclusively as [b].

Throughout the data collection period, the target production of some plosives alternated occasionally with the sound [t]. This was also observed for the production of the fricative /s/.

Age	p	Sub	b	sub	t	sub	d	sub	k	sub	g	sub
2;5	75	[t]	100		92	[p]	80	[t]	100		80	[t]
2;6	77	[t], [b], [f]	89	[m]	91	[ts]	78	[t]	83	[t], [s]	64	[k], [t]
2;7	75	[b], [m]	89	[v]	92	[l]	100		83	[t], [s], [b]	64	[k], [t], [d]
2;8	0	[b], [m]	n/d		n/d	[s]1	n/d		n/d		0	[k]
2;9	0	[b], [t]	n/d		n/d	[s]1	0	[t]	n/d	[t]1	0	[k]
2;10	100		100		89	[s]	100		100		100	
2;11	100		100		100		100		92	[g]	61	[k]
3	55	[b], [m]	100		87	[tʃ]	90	[t]	100		100	
3;1	70	[b]	100		67	[tʃ], [d], [ʔ]	100		100		89	[d]
3;2	0	[b]	0	[p],[t]	0	[tʃ], [k]	n/d		n/d		n/d	[k]1
3;3	87	[b]	92	[d]	100		100		91	[ʔ]	100	
3;4	92	[b]	100		100		100		100		91	[k]

Table 6-2: English plosive consonants acquisition and substitution patterns

2. Fricatives

At the end of the data collection period, two phonemes /f/ and /s/ were mastered. Phoneme /z/ reached acquisition level, while /v/'s acquisition pattern was not stable and scored below customary level at the end of data collection period. Interdentals reached customary level at the end, while /ʃ/ was realized as [s]. Regarding the substation patterns of fricatives, it seemed that devoicing and stopping were the most common errors found in AM's production of fricatives.

Age	F	sub	v	sub	θ	sub	ð	sub	s	sub	z	sub	ʃ	sub
2;5	66	[t], [p]	33	[p], [b]	50	[t], [f]	50	[d] 1	100		25	[s]	n/d	[1]
2;6	60	[s], [k], [p], [w], [θ]	66	[l]	63	[k], [f], [s]	100		100		50	[ð], [d], [s]	0	[s], [t]
2;7	63	[s], [p]	50	[s]1	66	[w]	100		87	[t], [f]	85	[s]	0	[s]
2;8	0	[s], [θ]	0	[b], [s], [w]	0	[t], [s]	n/d		n/d		n/d	[s]1	0	[s] 1
2;9	0	[s]	0	[p], [f], [fs], [z]	0	[s]1	n/d	[d] 1	n/d		n/d		0	[s]
2;10	80	[p]	66	[b]	66	[s]	83	[d]	100		66	[ð]	0	[s]
2;11	100		33	[p], [f]	66	[s]	n/d		91	[ʃ]	81	[ð], [s]	0	[s]
3	100		100		100	[1]	66	[d]	90	[t]	75	[ð], [s]	0	[s]
3;1	77	[s], [b]	80	[f]	100	[1]	80	[d]	94	[t]	71	[ð]	66	[s]
3;2	0	[ʃ]	n/d		0	[θʃ], [ʃ]	n/d		n/d	[t] 1	0	[s], [ʃ], [θ]	0	[s]
3;3	100		100		40	[ʃ], [f]	80	[d]	90	[d]	55	[s], [ʒ]	12	[s]
3;4	100		28	[f]	50	[f], [s]	62	[f]	100		77	[s], [ʃ]	0	[s]

Table 6-3: English fricative consonants acquisition and substitution patterns

3. Nasal, approximant and affricate consonants

3.1 Nasals

at the beginning of the data collation period, AM's nasals were mastered and relatively stable, except for the phoneme /ŋ/. His acquisition and development of this

phoneme has undergone periods of regression and alternated with /ŋg/ and /ŋk/. It showed no sign of stabilization near the end of the data collection period.

3.2 Approximants

The phoneme /ɹ/ was predominantly realized as either [ɾ] or [l], with low accuracy level. At 2;7 years old, his correct production had reached customary level and was the highest level throughout the data collection period.

On the other hand, though the phoneme /l/'s accuracy production percentage was much higher, it was realized as either [ɹ] or [r] occasionally. Its production fluctuated between mastery and acquisition levels until it was mastered at the end of data collection period.

3.3 Affricates

AM's acquisition pattern for his English affricates was developmental, even though it went through periods of fluctuation. A dramatic change of his acquisition of English affricates took place after the participant reached 2;11 years old as demonstrated by Table 6-4. After that, a sudden peak in his acquisition was evident and reached customary and mastery levels for /tʃ/ and /dʒ/ respectively. However, at the end of data collection, his attainment reached acquisition and customary levels for /tʃ/ and /dʒ/ respectively. The most occurring error pattern observed seemed to be deaffrication, where /tʃ/ and /dʒ/ production alternated with /t/ and /d/ respectively. In comparison with /tʃ/, /dʒ/ appeared to have higher accuracy overall levels, even though at the end of data collection /tʃ/ scored relatively higher in terms of accuracy of production. The substitution pattern of the affricate /tʃ/ exhibit an alternation with

two sounds: [t] and [s]. It was observed that it alternated with [ʃ] at two months, only 3 and 3;2. At the same period, the fricative /ʃ/ was realized as [s] exclusively.

Age	m	sub	/n/	ŋ		ɹ	sub	L	sub	tʃ	sub	dʒ	
2;5	100		100	50	[ŋg]	0	[l], [r]	100		n/d		0	[d]1
2;6	100		100	83	[ŋk]	15	[l], [r], [n], [t]	92	[r]	11	[s], [t], [ts]	33	[d], [dz], [ds]
2;7	100		100	50	[ŋg]	50	[r], [l]	77	[ɹ], [p]	14	[s], [t], [ts]	0	[d], [dz]
2;8	n/d		n/d	n/d		n/d		100		0	[s], [t], [ts]	0	[d], [dz]
2;9	n/d		n/d	n/d		0	[l], [r], [n]	0	[n], [j], [ɹ]	0	[s], [t]	0	[d], [s], [g], [gz]
2;10	100		100	n/d	[1]	35	[l], [r]	100		0	[s], [ts], [t]	n/d	
2;11	100		100	33	[ŋk], [ŋg]	42	[l], [r]	86	[ɹ]	71	[s], [t]	100	
3	100		100	100		35	[l], [r]	80	[r]	0	[ʃ]	100	
3;1	90	[n]	100	67	[ŋk], [ŋg]	15	[l], [r], [m]	62	[r], [n]	57	[t], [s]	67	[dz]
3;2	n/d		n/d	0	[ŋg]	0	[l], [r]	n/d		0	[ʃ], [s]	n/d	
3;3	100		100	75	[ŋg]	15	[l], [r]	83	[r]	75	[t], [s]	100	
3;4	100		100	40	[ŋg]	27	[l], [r], [ʌ]	93	[t]	80	[t]	71	[d], [z]

Table 6-4: English nasal, approximant and affricate consonants acquisition and substation patterns

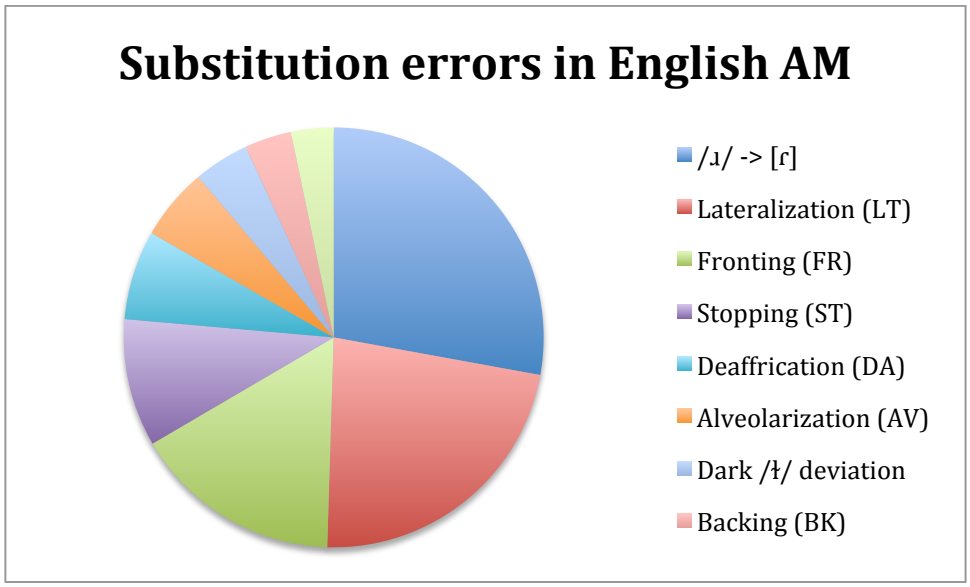
6.1.1.3 Error analysis

A. Type analysis

1.1 Substitution error patterns

Graph 6-1 illustrates the frequency percentage of substitution error types. The substitution of the phoneme /ɹ/ -> [ɾ] had the highest frequency of occurrence among the substitution errors, with a total percentage of 32%. Lateralization error pattern was the second highest, with a frequency of 26% of substitution error pattern. The third most frequent substitution error was fronting, with a 19% frequency score. Moreover, stopping error pattern score reached 11% of total substitution error pattern. Lastly,

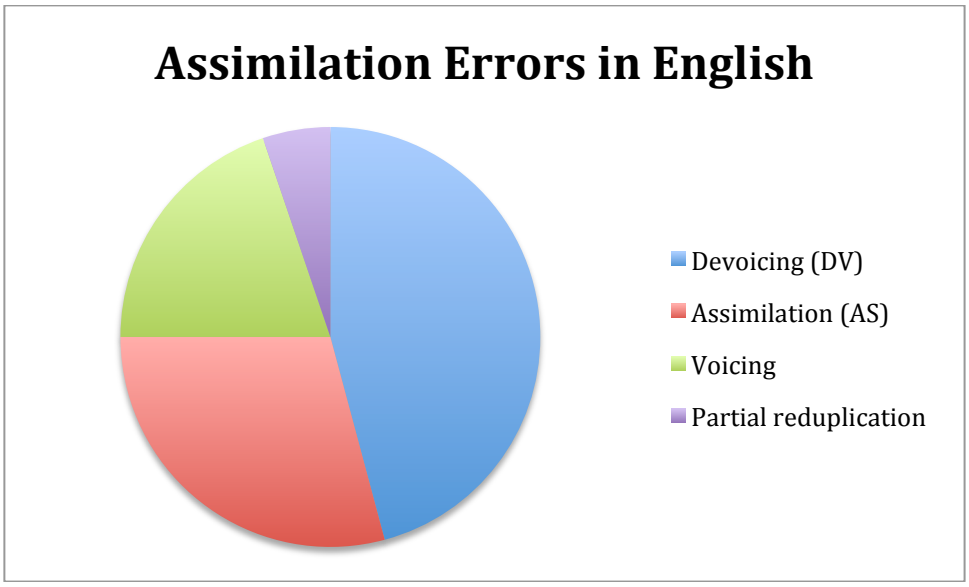
alveolarization, deaffrication and dark /ɬ/ deviation error patterns occurred with less than 10% frequency scores.



Graph 6-1: Substation error patterns in English

1.2 Assimilation

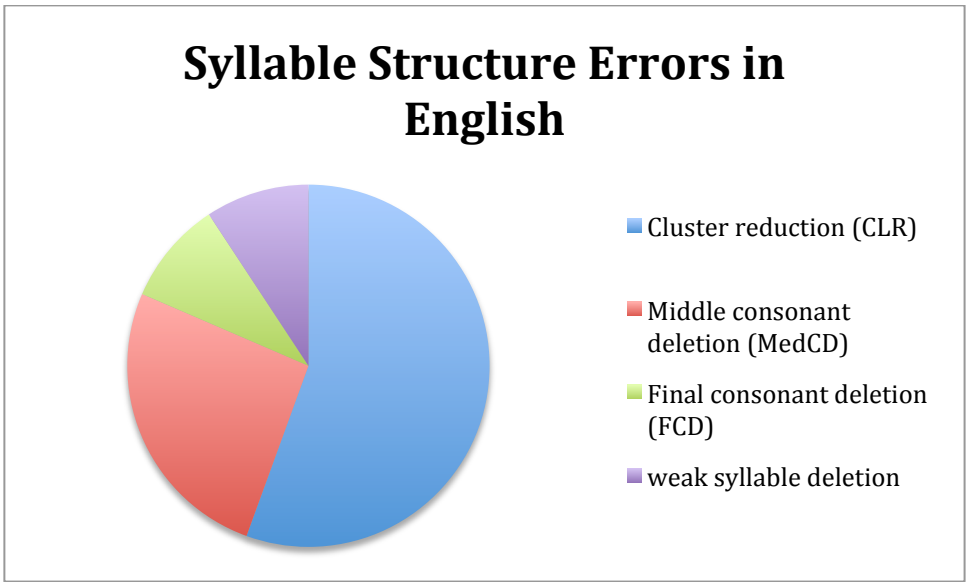
The total number of assimilation errors identified in the participant's speech sample was significantly lower than substitution errors. The most pronounced types of assimilation errors in the data were devoicing, assimilation, voicing and partial reduplication. The frequency of devoicing error pattern was relatively high, occurring in 46% of total assimilation error patterns, while voicing had a lower impact on the participant's speech and was identified in 20% of total assimilation error patterns. In addition, assimilation occurred with 29% frequency of total assimilation error. Partial duplication error pattern seemed to score the least among this type of error pattern.



Graph 6-2: Assimilation error patterns in English

1.3 Syllable structure errors

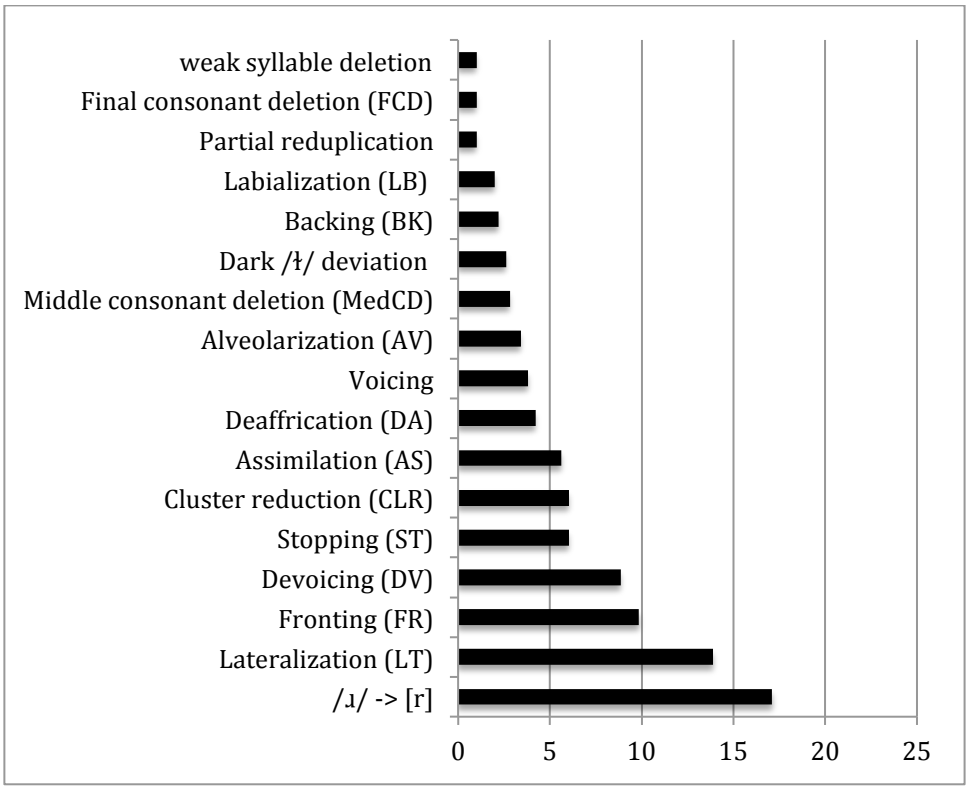
More than half of the error patterns identified under syllable structure error pattern fell under cluster reduction, with 56% frequency of total syllable structure errors. Regarding consonant deletion, the participant had a higher tendency to delete middle than final consonants, with a 17% frequency difference. In addition, weak syllable deletion had comparable frequency of occurrence, with final consonant deletion of 9% of total syllable structure error patterns.



Graph 6-3: Syllable structure error patterns in English

1.4 Overall error patterns in English

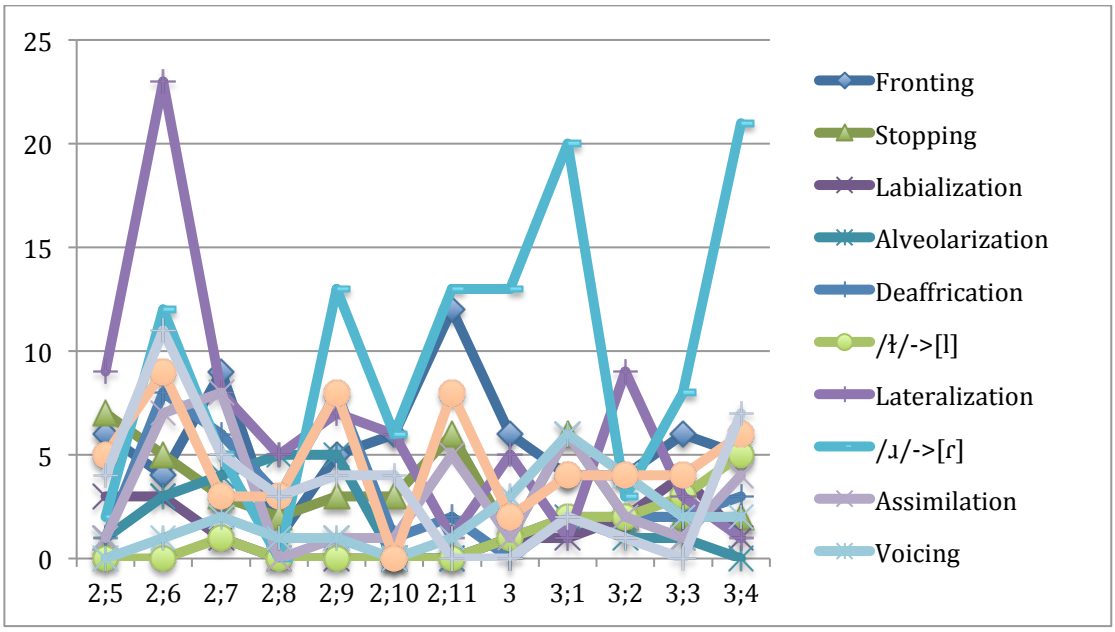
Graph 6-4 illustrates overall error patterns in English. Substitution error patterns were the highest occurring error type. The substitution of the phoneme /ɹ/ -> [ɾ] had the highest frequency of occurrence among all errors, followed by lateralization accounting for 17% and 13% of total error patterns respectively. The least frequently occurring error patterns in the participant's production were partial reduplication, final consonant deletion and weak syllable deletion scoring 1% of total error patterns.



Graph 6-4: Overall error patterns in English language

2. Frequency analysis

Graph 6-4 demonstrates frequency analysis of error patterns over data collection period. Most error patterns illustrated a general decrease trend after periods of fluctuation except for /ɹ/ and /ɬ/ deviation error patterns, which exhibited noticeable increase throughout the data collection period. Moreover, an interesting tendency was observed between lateralization and /ɹ/ deviation error patterns; at the periods of high scores of lateralization error, /ɹ/ deviation had low occurrences. Later, where a noticeable decrease of lateralization errors was observed, a spike of /ɹ/ deviation error patterns was noticed.



Graph 6-5: Longitudinal frequency analysis of error patterns in English

6.1.2 Arabic data

6.1.2.1 Percentage consonant correct (PCC)

Table 6-5 illustrates the participant's Arabic PCC results. The participant's accuracy of production slightly decreased 1.8% from 2;6 to 3;4 years.

PCC	Arabic
2;6	70.52%
3;4	68.6%
Average	69.56%

Table 6-5: PCC in Arabic

6.1.2.2 Phonemic repertoire

1. Plosive consonants

AM's acquisition of his plosive in Arabic seemed to have been mastered early, except for the phoneme /q/. Even though he was able to reach the target

pronunciation, its production alternated with [g] and [k] frequently. The phoneme /q/ is a late acquired sound by monolinguals and typically alternates with the sound [g] in various varieties of Arabic language, as discussed before. As for the phoneme /b/, it exhibit an early mastery, but its accuracy had fallen to acquisition level at the last two months of data collection. This fall was due to some error patterns such as metathesis; for example, /mətˤbaχ/ for kitchen was pronounced as [məbtˤaχ]. Thus, it is not an indication of regression.

Age	b	sub	t	sub	d	sub	k	sub	g	sub	q	sub
2;5	100		100		85	[t]	100		100		0	[g]
2;6	83	[m], [l]	100		100		86	[t]	40	[d], [k]	100	
2;7	100		100		100		100		50	[k]1	n/d	[b]1
2;8	100		100	[1]	100		100	[1]	n/d		n/d	
2;9	n/d	[l]1	n/d		n/d		n/d		0	[d]1	n/d	
2;10	100		60	[d], [s]	86	[t]	88	[tʃ]	66	[k]	40	[g], [k]
2;11	100		100		100		100		100		50	[g]1
3	100		100		100		100		100		50	[g]1
3;1	100		100		n/d		100		100		n/d	
3;2	100		100		91	[t]	100		100		n/d	[g]1
3;3	86	[f]	100		100		100		100		n/d	
3;4	81	[ʔ], [tˤ]	100		100		90	[t]	100		0	[k], [g]

Table 6-6: Arabic plosive consonants acquisition and substitution patterns

2. Fricative consonants

2.1 Labiodental, alveolar and post alveolar consonants

Table 6-7 demonstrates early mastery of phonemes /f/, /s/ and /z/. However, the acquisition of the phoneme /z/ had regressed dramatically to customary level at the last month of data collection period, and its target alternated with its voiceless counterpart [s]. On the other hand, /ʃ/ rarely reached its target throughout the data collection period. It was frequently realized as the sound [s] and never reached even customary level.

2.2 Uvular consonants

The phoneme /χ/ had a steady developmental pattern throughout the data collection period, and its attainment fluctuated between mastery and acquisition levels. It was substituted on different occasions with the pharyngeal [ħ] and mastered at 3;3. As for the phoneme /ʁ/, there was not enough data to account for its acquisition pattern.

2.3 Interdentals

Whereas /θ/'s acquisition exhibits fluctuation, its voiced counter-part /ð/'s acquisition pattern appear stable. At the end of data collection, /θ/ did not reach its target value, while /ð/ reached mastery production. However, this conclusion should be approached with caution, since the participant's production was judged on two accounts.

Age	f	sub	θ	sub	ð	sub	S	sub	z	sub	ʃ	sub	χ	sub	ʁ	sub
2;5	75	[b], [t]	100		75	[d]	88	[b]	100		33	[s], [t]	87	[ħ]	100	[1]
2;6	78	[s]	100		100	[2]	86	[θ]	100		0	[ts], [s]	80	[h]	n/d	
2;7	66	[θ]	66	[t]	100	[2]	100		100		0	[s]	n/d		n/d	
2;8	100	[1]	n/d		n/d		100		n/d	[l]1	n/d		100		n/d	
2;9	n/d		n/d	[t]1	n/d		n/d		n/d		n/d		100		n/d	
2;10	100		33	[s]	100		86	[θ]	100		10	[s]	86	[ħ]	33	[w], [χ]
2;11	100		86	[d]	100		100		75	[d]	0	[s]	100		0	[ʔ]1
3	100		40	[s], [f]	100		93	[t]	80	[ʔ]	0	[s]	86	[d]	100	[2]
3;1	100		n/d		n/d	[1]	100		n/d		n/d		100		n/d	
3;2	100		100		100	[2]	100		100		28	[s]	87	[k]	100	[1]
3;3	100		66	[l]	80	[d]	100		100		0	[s], [k]	100		50	[h]1
3;4	100		0	[s]	100	[2]	100		66	[s]	25	[s], [f]	100		100	[1]

Table 6-7: Arabic fricative consonants acquisition and substitution patterns

3. Emphatic and pharyngeal consonants

As far as the acquisition pattern of emphatic and pharyngeal consonants are concerned, it seemed that the participant demonstrated higher acquisition levels for pharyngeal consonants, while his emphatics rarely met its target production except for phoneme /tˤ/, which reached customary level at the end of data collection period. It is important to note the difficulty of evaluating his acquisition of emphatics due to limited opportunities of production. The most predominant error patterns deployed by AM when producing these phonemes were de-emphasis and de-pharyngealization, in which they are simplified and realized as their plosive and fricative counter-parts.

For the pharyngeal consonants /ħ/ and /ʕ/, it is apparent from Table 6-8 that the phoneme /ħ/ was mastered at 3;2. As for the phoneme /ʕ/, it demonstrated a mastery level during the period of 2;11 right at the end of data collection period, where it fell to customary level at the last month. As for the substation pattern, /ħ/ alternated with [h], and /ʕ/ was frequently realized as [ʔ].

Age	ħ	sub	ʕ	sub	tˤ	sub	sˤ	sub	ðˤ	sub	dˤ	sub	lˤ	sub
2;5	92	[h]	88	[ʔ]	22	[t], [d]	0	[s]	n/d		0	[l]1	n/d	
2;6	100		100		50	[d]1	14	[s]	n/d		0	[l]1	n/d	
2;7	77	[h]	100		33	[d]	0	[s]	n/d		n/d		0	[l]
2;8	100		50	[ʔ]	100	[1]	n/d		n/d		0	[ð]1	n/d	
2;9	n/d		n/d		n/d		0	[θ], [s]	n/d		n/d		0	[l]
2;10	77	[h]	55	[ʔ]	8	[t], [d]	0	[s], [t]	0	[ð]	0	[ð]	0	[l]
2;11	83	[h]	100		14	[t], [d]	0	[s]	n/d		0	[ð], [d]	n/d	
3	100		100		100	[1]	0	[s]	n/d		n/d		n/d	
3;1	87	[h]	n/d		n/d		n/d		n/d		n/d		n/d	
3;2	92	[χ]	92	[ʔ]	50	[t], [d]	33	[s], [f]	0	[z]1	n/d		n/d	
3;3	100		90	[ʔ]	0	[t], [d]	0	[s]	0	[z]1	n/d		n/d	
3;4	100		50	[ʔ], [h]	50	[b], [t]	0	[s]	n/d		0	[d], [m]	0	[l]

Table 6-8: Arabic pharyngeal & emphatic consonants acquisition and substitution patterns

4. Nasal, approximant and affricate consonants

4.1 Nasals

Since the beginning of the data collation period, AM's nasals were mastered and relatively stable. Few substitutions were observed occasionally.

4.2 Tap or flap /ɾ/

The acquisition pattern of the phoneme /ɾ/ followed a normal development trend, with few fluctuation periods. From the beginning of data collection up to age 3;2, it followed a gradual developmental curve, starting from 36% and reaching up to mastery. Nonetheless, his accuracy of production regressed to reach customary level at the end of data collection. For the substation pattern, it mainly alternated with the lateral approximant [l] and infrequently with its English counter-part [ɹ].

4.3 Lateral /l/

As for the acquisition and development for the phoneme /l/, it was acquired and stabilized early with few sporadic replacements.

4.4 Affricate

The acquisition of the phoneme /dʒ/ proved to be very challenging to AM throughout the data collection. The predominant error pattern that was deployed was deaffrication. This affricate was realized mostly as [d] and [z] and on occasions as

[dz]. His production had reached a mastery level at 3;1 only to regress thereafter and reach 25% at 2;4. However, it is important to note that at 3;1 there were only two elicited lexical items produced with the target phoneme in which it reached the target value.

Age	m	sub	n	sub	r	Sub	l	sub	j	sub	ʤ	sub
2;5	100		100		36	[l], [t], [d], [ɹ]	100		100		20	[d]
2;6	82	[l], [n]	90	[m]	53	[l], [b], [d], [ɹ]	100		100		11	[d], [dz]
2;7	100		86	[l]	58	[ɹ], [l]	90	[n]	100		0	[dz], [d]
2;8	100		86	[ʔ]	37	[l]	100		100		0	[d], [z]
2;9	n/d		n/d		36	[l], [ɹ]	n/d		n/d		0	[d], [ʔ]
2;10	100		100		68	[l], [ɹ], [d]	92	[ð]	83	[g]	8	[d], [g]
2;11	100		91	[m]	83	[l]	100		100		60	[d], [dz]
3	100		88	[ʔ]	75	[l], [ʁ]	100		100		57	[d], [z]
3;1	100		100		100		100		100		100	[2]
3;2	100		100		100		100		100		57	[d], [z]
3;3	100		100		83	[l]	100		100		33	[d], [z]
3;4	100		100		66	[l], [ɹ]	100		100		25	[d], [z], [dz]

Table 6-9: Arabic nasal, tap/ flap, lateral and affricate consonants acquisition and substitution patterns

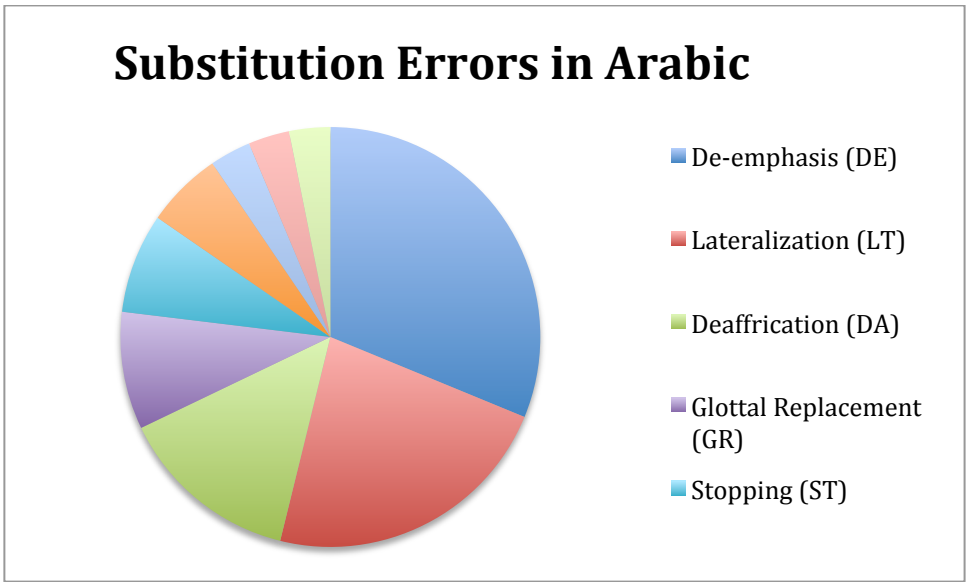
6.1.2.3 Error analysis

1. Type analysis

1.2 Substitution errors

The most frequently occurring error patterns were de-emphasis and lateralization, which accounted for 24% and 23% of total substitution error respectively. On the other hand, labialization, backing and de-pharyngealization were the least frequent errors, each counting for 3% of all substitution errors. Deaffrication error pattern demonstrated a high level of occurrence, with 14% of all substitution

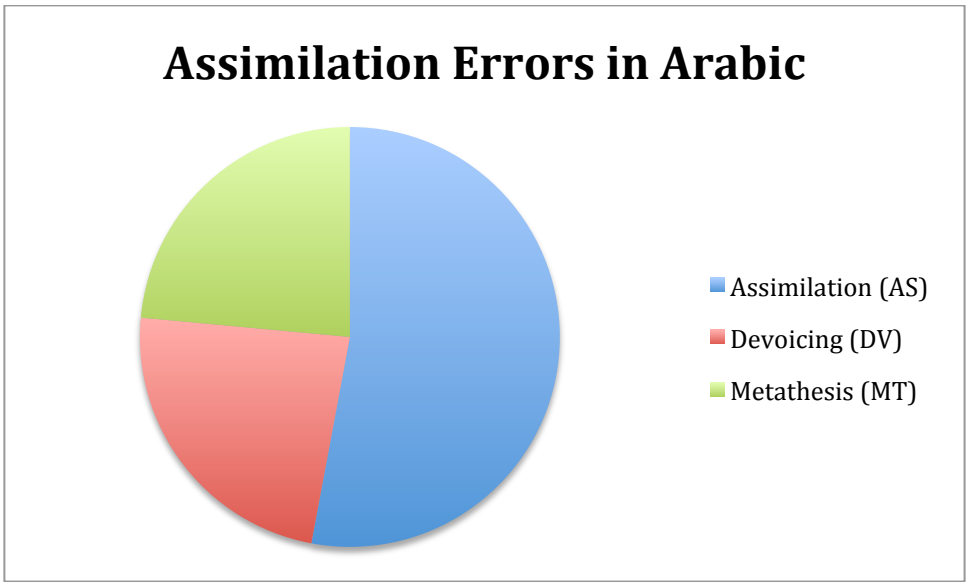
errors. Three errors were found to have similar percentage of occurrence; glottal replacement, stopping and fronting, scoring 9%, 8% and 6% respectively.



Graph 6-6: Substitution error patterns in Arabic

1.2 Assimilation

Assimilation errors were less frequent than substitution error patterns. The most frequent assimilation errors identified were assimilation, devoicing and metathesis, which accounted for 53%, 24% and 24% of total assimilation errors respectively.



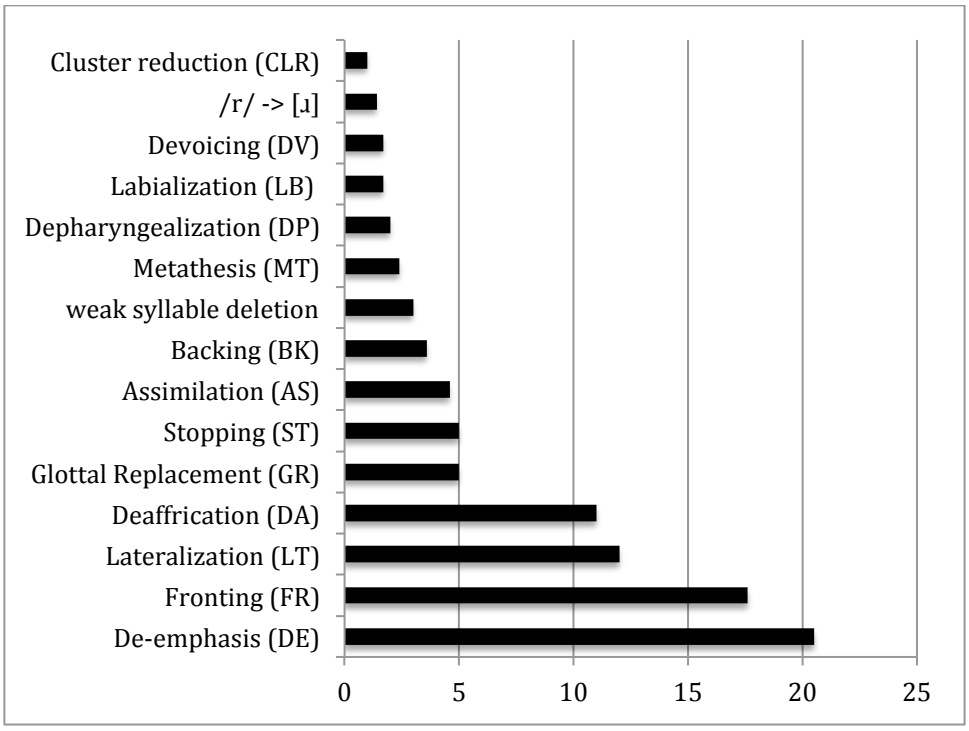
Graph 6-7: Assimilation error patterns in Arabic

1.3 Syllable structure errors

Syllable structure error patterns were infrequent. The two most frequent error patterns recognized are weak syllable deletion and cluster reduction, accounting for 58% and 21% of all syllable structure errors.

1.4 Overall error patterns in Arabic

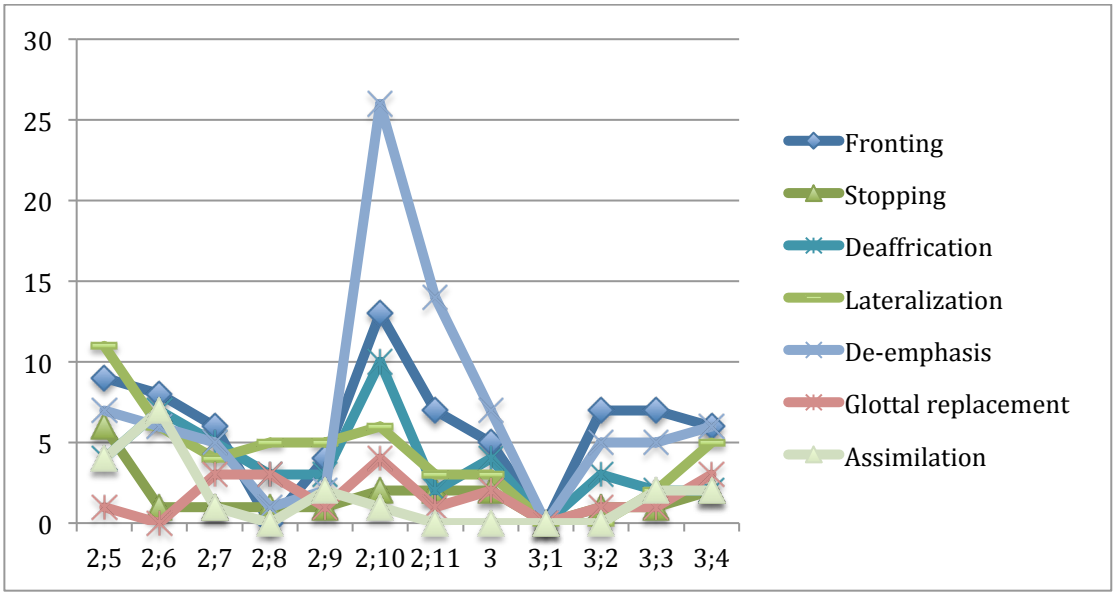
De-emphasis, fronting, lateralization and deaffrication were the most frequently occurring error patterns identified in the participant's Arabic production, scoring more than 10% as demonstrated in Graph 6-8. Stopping, glottal replacement reached comparable values of around 5% each, while rest of the error patterns' frequencies of occurrence were under 5%.



Graph 6-8: Overall error patterns in Arabic language

2. Frequency analysis

Graph 6-7 illustrates the frequency analysis of error patterns produced throughout data collection period. Most error patterns demonstrated an overall gradual decrease of occurrence, with occasional fluctuation.



Graph 6-9: Longitudinal frequency analysis of error patterns in Arabic

6.1.3 Comparison between English and Arabic acquisition

6.1.3.1 Percentage Consonant Correct (PCC)

Table 6-10 illustrates the participant's PCC across languages at the beginning and end of the data collection period. At age 2;6 years, the participant had similar PCC scores cross-linguistically. However, at the end of data collection, a percentage of 8.5% differences across his languages were observed.

PCC	English	Arabic
2;6	69%	70.52%
3;4	76.7%	68.6%
Average	72.85%	69.56%

Table 6-10: English and Arabic PCC results

6.1.3.2 Phonemic repertoire

1. Plosives

Both of Arabic and English plosives were acquired at the beginning of data collection when he was 2;5 years old. However, his accuracy in Arabic predominated his English accuracy of production, where Arabic plosive consonants appeared to be mastered at 2;10 except for phoneme /q/. English plosives were mastered later than their Arabic counterpart, at around 3;3.

The phoneme /g/ was mastered and stabilized in Arabic before its English counterpart. It stabilized at 2;11 in Arabic with 100% accuracy, while in English it was still being substituted with [k] up to the end of data collection. Nevertheless, the

phonemes /k/ and /g/ displayed similar development patterns across the two languages. In addition, the phoneme /d/ was mastered in both languages at the beginning of data collection; it occurred in alternation with its voiceless counterpart [t] in English and Arabic and stabilized early.

2. Fricatives

The phoneme /f/ was mastered one month earlier in Arabic than English at age 2;10 years old. Interdentals seemed to follow similar trends, though it is hard to determine their acquisition pattern at times due to limited production opportunities. In addition, /s/ was acquired earlier in English, while /z/ demonstrated fluctuation; it reached customary level in English but showed variability in Arabic, moving from mastery to acquisition levels and reaching customary level only at the last month of data collection period. Phoneme /ʃ/, on the other hand, followed the same acquisition trends, where it rarely reached its target cross-linguistically and was frequently realized as [s].

3. Nasals

Shared nasals were mastered at the beginning of data collection period.

4. Lateral approximant

Clear /l/ was mastered early cross-linguistically. Interestingly, its target value alternated with phoneme [ɹ] and [r], which corresponds to his substitutions of his

targets /r/ and /ɹ/ into /l/. His substitution patterns for target /l/ and /ɹ/ in English were noteworthy. However, for Arabic, he would only alternate [l] for the target /r/ but not vice versa.

5. Acquisition of English /ɹ/ and Arabic / ɾ /

Even though the Arabic and English /r/ share a similar place of articulation, they differ in the manner of articulation. It was observed that the target phoneme /ɹ/ frequently alternated with the sounds [r] and [l] in English. Similarly, the target Arabic /ɾ/ alternated with [ɹ] and [l] in Arabic. This lateralization error pattern seemed to be deployed cross-linguistically. In addition, bi-directional interaction was observed in terms of the production of English /ɹ/ and Arabic /ɾ/ across languages. However, the accuracy of production of the Arabic /r/ is much higher. In Arabic, it reached 100% at 3;1,2, while the highest accuracy score of the English /ɹ/ reached customary at 2;7. Longitudinally, the accuracy of the Arabic /ɾ/ moved from 36% to 66%, while in English it developed at a slower pace, from 0% accuracy to 27%. To conclude, the acquisition and development paths of the Arabic /ɾ/ and English /ɹ/ share some similarities. Overall, the mastery and accuracy level of Arabic is higher than English in regards to this phoneme.

5. Affricate

Shared affricate /dʒ/ demonstrated higher acquisition levels for English than Arabic as illustrated by Table 6-11. It fluctuated from mastery to acquisition level in English, while it reached customary level most of its production in Arabic. Regarding

substitutions, its target alternated with the sounds [d], [z] and [dz] throughout the data collection period cross-linguistically.

AM	English			Arabic		
Age	Mastery production (>90%)	Acquisition production (75-89%)	Customary production (50-74%)	Mastery production (>90%)	Acquisition production (75-89%)	Customary production (50-74%)
2;5	/b/, /t/, /k/, /m/, /n/, /s/, /l/, /j/, /w/	/p/, /d/, /g/	/p/, /ŋ/, /θ/, /ð/, /z/,	/b/, /t/, /k/, /ʔ/, /m/, /n/, /z/, /h/, /j/, /w/, /l/,	/f/, /s/, /χ/, /ʕ/,	/g/,
2;6	/t/, /l/	/p/, /d/, /k/	/g/, /ŋ/, /θ/, /v/, /z/,	/b/, /d/, /z/, /h/,	/f/, /s/, /χ/,	/g/, /ɾ/,
2;7	/t/, /d/, /l/	/p/, /k/	/g/, /ŋ/, /θ/, /v/, /z/, /ɹ/,	/b/, /s/, /z/, /h/,		/g/, /θ/, /f/ /ɾ/,
2;8	/l/		/ŋ/, /θ/, /z/,	/b/, /z/, /h/,		/g/, /ʕ/,
2;9	/l/		/ŋ/, /θ/, /z/,	/b/, /z/,		/g/,
2;10	/p/, /k/, /g/, /l/	/t/, /ð/, /f/,	/t/, /ŋ/, /θ/, /v/, /z/,	/b/, /g/, /f/, /z/, /ð/,	/ʃ/, /χ/, /h/,	/g/, /ɾ/,
2;11	/p/, /b/, /g/, /f/, /dʒ/	/t/, /ð/,	/g/, /ŋ/, /θ/, /z/,	/b/, /ʕ/, /ð/,	/z/, /ʃ/, /χ/, /h/, /ɾ/,	/dʒ/,
3	/dʒ/	/t/, /ð/, /v/, /ɹ/,	/ŋ/, /θ/, /z/,	/b/, /ʕ/, /ð/,	/z/, /χ/, /h/, /ɾ/,	/dʒ/,
3;1		/p/, /g/, /ð/, /dʒ/	/ŋ/, /θ/, /z/,	/b/, /ʕ/, /ɾ/,	/χ/, /h/,	/dʒ/,
3;2		/p/, /ð/	/ŋ/, /θ/, /z/,	/b/, /z/, /h/, /ʕ/, /ɾ/,	/χ/,	/tˢ/, /dʒ/,
3;3	/t/, /g/, /dʒ/	/p/, /ð/, /tʃ/	/ŋ/, /θ/, /z/,	/z/, /χ/, /ʕ/,	/b/, /ɾ/, /ð/,	/tˢ/, /θ/,
3;4	/p/, /l/	/z/, /dʒ/	/ŋ/, /θ/, /ð/,	/ð/,	/b/,	/tˢ/, /z/, /ʕ/, /ɾ/,

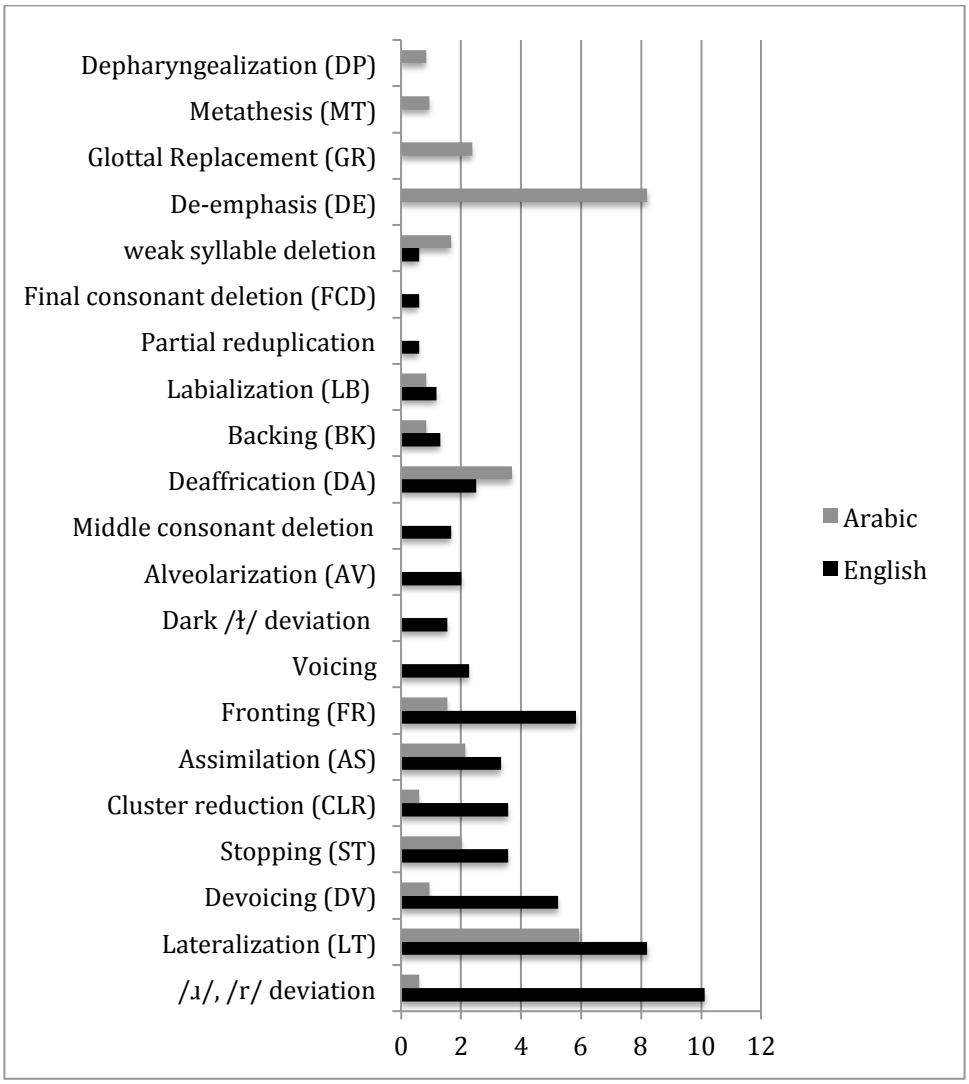
Table 6-11: English and Arabic phonemic inventories
Note: highlight indicate fluctuations

6.1.3.3 Error analysis

1. Type analysis

Graph 6-8 illustrates error pattern frequency of occurrence across the participant's languages. Some error patterns, such as /ɹ/ deviation, devoicing, cluster reduction and fronting, had dramatically higher frequency scores in English compared to Arabic. It is clear that the most frequently occurring error was /ɹ/ deviation in English, accounting for 10% of the total error patterns. Nonetheless, this error type existed with low frequency in Arabic, reaching .5%. Other error types, like stopping,

assimilation, backing and labialization, were relatively higher in English than in Arabic, while deaffrication and weak syllable deletion occurred with relatively higher frequency in Arabic than in English. In addition, the participant exhibited great tendency toward substituting /ɹ/ and /ɾ/ for the lateral [l]. Lateralization was identified in his speech sample cross-linguistically, scoring 8% and 6% respectively. On the other hand, some error patterns were language specific. For example, voicing, alveolarization, dark /ɬ/ deviation, middle consonant deletion and final consonant deletion only existed in the participant's English sample, whereas de-emphasis, glottal replacement, metathesis and de-pharyngealiztion occurred in Arabic data only. Moreover, de-emphasis had a high frequency score, counting for 8% of total error patterns. De-emphasis is a language-specific error because emphatics only occur in Arabic.



Graph 6-10: Comparison between English and Arabic error patterns

2. Frequency analysis

Frequency analysis of error patterns across languages revealed similar tendencies. In both languages, most of the error patterns demonstrated fluctuation, with an observable drop in occurrences. Some exceptions were glottal replacement in Arabic and /ɹ/ deviation in English, in which higher frequencies were observed over time.

6.2 Summary and discussion

6.2.1 Summary

6.2.1.1 Segmental acquisition

Transfer

Evidence of transfer was observed in the participant's production of three segments: English phonemes /ŋ/ and /ɹ/ and Arabic phoneme /ɾ/. English-speaking children were reported to master the nasal velar /ŋ/ early, between two and three years (McIntosh & Dodd, 2008). AM's acquisition did not extend beyond customary level for that phoneme, and it alternated with the sounds [ng] or [nk] at 45% of its total production. Moreover, his acquisition did not show any signs of stabilization during the data collection period. Interestingly, this error pattern was not observed in the production of the other two participants; this could be attributed to higher language exposure in Arabic, which could have had a direct effect on the acquisition of language-specific features of his weaker language. In terms of the participant production of the English approximant alveolar /ɹ/, 44% of its total production was realized as alveolar tap /ɾ/. At the end of data collection, /ɹ/ was realized as /ɾ/ 68% of its production, showing no sign of stabilization. Moreover, the 60% of its production that was not produced as its target was lateralized into [l] for 30% of its total production. The intensity of this error pattern had decreased over the period of its acquisition. Regarding the acquisition of Arabic /ɾ/, the data indicate that a small percentage of its target production was realized as the approximant alveolar /ɹ/ but

with lesser frequency and occurred in only 5% of its total production. It seemed that his Arabic language, where he had received more language exposure, had a bootstrap effect in filling in any potential lack of proficiency by utilizing elements specific to one language in the acquisition of his other language, which has been observed widely in bilingual acquisition literature (Gawlitzek-Maiwald &Tracy (1996); Keshavarz & Ingram, 2002). Lateralization was also observed in the participant's production of Arabic phoneme /ɾ/, occurring in 23% of its total production. The frequency of this error pattern fell dramatically at the end of data collection period.

Acceleration and delay

The segmental analysis indicated that AM mastered the following English phonemes between 2;5-3 years: stops /b, d, k/, fricatives /f, s/ and nasals /m, n/. Compared to McIntosh and Dodd's (2008) study, the participant's acquisition appeared to be delayed in terms of the segments /p, t, g/ and velar nasal /ŋ/. Meanwhile, he mastered the fricative /f/ before English monolingual children reported in ibid. The phonemes /d/, /k/, /s/, /m/ and /n/ were found to be mastered at a comparable age to monolingual children. In regards to his intermediate sounds, which were acquired between 3;1-3;4, his inventory expanded to include the phonemes /p/, /l/ and /t/. For this period, a delay of acquisition was observed for the phonemes /ʃ/, /z/ and /tʃ/.

Cross-linguistic divergence was evident in the participant's acquisition of phonemes. For his Arabic inventory, he mastered the following segments before three years: plosives /b, t, d, k, g, ʔ/, nasals /m, n/, fricatives /f, s/ and /l, j/. In comparison to Alqattan's (2015) findings, the participant had an accelerated acquisition for the

following segments: plosives /b/, /t/, /d/, /g/, nasal /m/, fricatives /f/, /s/, lateral approximant /l/ and approximant /j/. Two phonemes were added to his mastered inventory between 3;1-3;4: uvular /χ/ and pharyngeal /ħ/ fricatives. As far as these two fricative consonants are concerned, his acquisition appeared to be accelerated.

6.2.2 Error patterns

Age	2;5 -2;11		3;0- 3;4	
Language	E	A	E	A
1. Substitution error patterns				
Fronting	AM	AM	AM	AM
Backing				
Dentalization				
Stopping	AM	AM	AM	
Gliding				
De-affrication	AM	AM	AM	AM
De-emphasis		AM		AM
Lateralization of /r/	AM	AM	AM	AM
/ɾ/ ->/ɹ/				
/ɹ/->/ɾ/	AM		AM	
Glottalization				
2. Assimilation				
De-voicing	AM		AM	
Voicing			AM	
Assimilation	AM	AM	AM	
3. Syllable error patterns				
Final consonant deletion				
Cluster reduction	AM		AM	
Weak syllable deletion				

Table 6-12: AM error patterns across English and Arabic speaking children

1. Language-specific error patterns

1.1 De-emphasis

De-emphasis was one of the most common error patterns reported in the speech production of AM and accounted for 20% of total errors during the period of

data collection. The participant de-emphasized 78% of target emphatics production between 2;5-2;7 years. A slight decrease could be observed at the end of the data collection period of around 66%, which indicated a case of deceleration compared to Arabic children monolinguals, who were reported to have reached 11% frequency of occurrence for the same error pattern. The same study reported that this error is considered an age-appropriate error for children between 1;4 and 3;7 and accounted for 36% of total error patterns. Similarity could be observed in terms of the high percentage of occurrence of this error pattern in the participant's production and Arabic-speaking children. Moreover, there seemed to be a steady decrease of frequency correlated with age in Alqattan's (2015) study and AM. Even though the progress rate of acquisition of emphatics by the participant is comparably slower, accounting for 12% at the end of data collection, it is developmental.

1.2 Glottal replacement

This error pattern was reported as an occasional error, and its frequency demonstrated an overall decrease after the participant turned three years old and was associated with periods of fluctuation. This error pattern was not common among Arabic monolinguals in Alqattan's (2015) study but was reported as an age-appropriate error by other Arabic acquisition studies. Therefore, the participant’s acquisition appears to follow monolingual norms.

2. Cross-linguistic error patterns

Lateralization was one of the most frequently occurring error patterns reported in the participant's speech production across his languages. Interestingly, this error was observed as the second most frequently occurring error pattern in both English and Arabic languages. Nonetheless, the total number of this error production is higher in English compared to Arabic and is attributed to the higher frequency of errors in English than Arabic production. In addition, the frequency of occurrence of this error pattern showed a steady decrease associated with a period of fluctuation across English and Arabic production. It was observed that the deviation of /r/ was the most frequently occurring error in the participant's production of English. In addition, between 2;5 and 2;7, the production of the English approximant /ɹ/ was realized as the tap [ɾ] 61% and then 65% at the end of data collection. Moreover, this substitution pattern increased over time as the lateralization pattern decreased. English and Arabic /r/, though, shared the same place of pronunciation and differed in the manner of production. Accordingly, error patterns observed by monolinguals of English and Arabic reflect that difference. It is common for Arabic-speaking children to lateralize the phoneme /ɾ/, while English-speaking children are reported to glide the approximant /ɹ/ before acquiring its target. Therefore, the participant's high frequency scores of lateralization reflected Arabic monolingual norms, while it exhibited divergence from acquisition norms in English. It appears that he utilized an age-appropriate error pattern in his dominant language to overcome the lack of proficiency in his weaker language.

The analysis of the data reveals higher frequency of stopping error pattern reported in the participant's production of English compared to Arabic. This error had

occasional occurrence in Arabic production, with a sharp decrease after the first month of data collection, while it reported a steady decrease after the age of three in his English production. Overall, the accuracy rate of fricative production was much higher in Arabic than in English for equivalent phonemes. It seems that the participant's production rate of stopping error pattern reflects monolingual norms of both English and Arabic children. It is crucial to point out that the stopping of the nasal /ŋ/ to [ŋg], [ŋk] was a persistent feature in his production and reflected not only monolingual norms but also cross-linguistic transfer.

Fronting was among the most frequently occurring error patterns in AM's speech production of English, while it was considered as an occasional error in his Arabic production. Moreover, its production demonstrated a subtle decrease over the period of his acquisition associated with periods of fluctuation across his languages. The participant's production of fronting error pattern reflected monolingual norms in the English language. While this error was observed to be rare among Arabic-speaking children, it was reported to have an occasional frequency in the participant's production. Therefore, the participant's acquisition may reveal an aspect of deceleration in respect to Arabic acquisition as far as fronting error is concerned.

Backing error pattern occurred at very low frequencies across the participant's English and Arabic production. Therefore, the production of this error demonstrates a case of convergence across the participant's phonological systems. Comparing the participant's result to monolingual production, it is concluded that his acquisition followed monolinguals' trends across English and Arabic.

The analysis of the results reveals a higher occurrence of deaffrication in the participant's production of Arabic than in his production of English. Deaffrication was observed to be an occasional error in his English speech, while it was reported among

the most frequently occurring error patterns in his Arabic production. However, it does not mean that this error is more persistent in Arabic than in English because the total number of errors reported in his Arabic speech data is much lower than in English. Therefore, it is reasonable to conclude that the participant had comparable acquisition levels of affricates. The participant's acquisition of affricates was comparable to English and Arabic monolingual norms.

Weak syllable deletion error pattern was reported to occur in low frequencies in the participant's production of English and Arabic. It seemed that the participant's low frequency score of weak syllable deletion error pattern reflected an aspect of acceleration compared to English monolinguals, while it conformed to Arabic monolingual norms. This pattern might also reflect an aspect of transfer in which the age-appropriate error pattern in his dominant language shapes the acquisition trajectory of his other language.

6.3 Discussion

Transfer was manifested in the production of three English phonemes /ɹ/, /ɬ/ and /ŋ/, which were realized as [ɾ], [l] and [ŋg, ŋk] respectively. This transfer was correlated to language exposure pattern of his linguistic environment, where he had higher language exposure to Arabic than the English language. At the end of data collection period, the participant returned to Saudi Arabia for three months; this change was an influential factor in the sharp increase in phonological transfer rate. It was also observed that transfer occurred for both segmental acquisition and error patterns. In that context, cross-linguistic ambiguity and language exposure behaviour contributed to noticeable frequencies of phonological transfer.

Acceleration is another aspect of cross-linguistic interaction. Some aspects of his Arabic phonemic acquisition appeared to be accelerated compared to monolinguals, but not his English acquisition. This acceleration could be reflective of individual differences or could be stimulated by the process of acquiring to distinct phonological systems. However, the last claim should be approached with caution since this acceleration was not observed for shared consonants. The bilingual environment is claimed to have a role in promoting phonological awareness of bilinguals which could lead potentially to a faster rate of acquisition than monolingual (Grech & Dodd, 2008).

Delay was observed to manifest in his acquisition of English phonemes compared to monolinguals, while error patterns were higher in both type and frequency than reported in English monolingual norms. Notably, shared phoneme segments were acquired in Arabic before English. Even though deceleration was observed, it is inconclusive whether it could be attributed to cross-linguistic interaction because the deceleration affected the language where he had less exposure.

7 Discussion and Conclusion

7.1 Discussion

The main aim of this study is to account for cross-linguistic interaction phenomena in the phonological development of three simultaneous bilingual children: MF (2;6 - 3;5, girl), SF (2;6 - 3;5, girl) and AM (2;5 - 3;4, boy). The children were acquiring Arabic and English simultaneously in the United Kingdom. Their families speak the same Arabic dialect (Gulf) and share similar socio-economic backgrounds.

A detailed account of their production of consonants and error patterns is presented longitudinally in each language. Multiple factors, such as sequential development, cross-linguistic interaction and language exposure patterns, were considered in data analysis.

Three research questions guided this investigation: (1) What are the phonological acquisition and development patterns for Arabic/English bilingual children in each language? (2) How does the phonological acquisition process of Arabic/English bilinguals differ from their monolingual peers in each language? (3) To what extent do the bilingual children's two phonological systems interact with each other during acquisition?

The aim of the first section of this chapter is to answer the first research question. The influence of individual variations and sequential development on the acquisition profiles of the participants is considered cross-linguistically. The second section explores the effect of cross-linguistic interaction on the age of PCC, phoneme acquisition and the development of error pattern. In accounting for cross-linguistic interaction, a comparison of the participants' acquisition and development against monolingual norms in each language is presented, thus providing an answer to the

second research question. A discussion of additional factors influencing the phonological acquisition trajectory of bilingual children is included. The final section discusses the main conclusion, limitation and implications of the study.

7.1.1 Phonological acquisition profile of Arabic/English bilingual children

The main findings of this study are presented in Tables 7-1 and 7-2. The influences of individual variations and sequential development are explored against the participants' PCC, phonemic inventories and error patterns.

Language		English			Arabic		
Participant		MF	SF	AM*	MF	SF	AM*
PCC	2;6	84.9%	73.5%	69%	55.5%	64%	70.52%
	Monolingual	Accelerated	Normal	Minor delay	Delay	Accelerated	Accelerated
(3;3*/3;4/3;5)		93%	91.6%	80.7/76.7%	66%	88.8%	79.5/68.6%
		Accelerated	Accelerated	Normal/delay	Delay	Accelerated	Normal/delay
Phonemic inventory	(2;4* - 3;00	/p, b, t, d, k/ /m, n, ŋ/ /f, ʃ, h/ /l, ɹ/ /tʃ, dʒ/ /w, j/	/b, p, k/, /t/ /s, f/, /h/ /m, n, ŋ/ /l/ /tʃ, dʒ/ /w, j/	/d, k/ /s/ /g/ /m, n/, /w, j, h/	/b, t, d, k, ʔ, g/ /m, n/ /f, h/ /w, j/	/b, d, t, k, ʔ/ /s, f/, /h/ /m, n/ /dʒ/ /w, j/	/b, t, d, k, g, ʔ/ /m, n/ /f, s, h/ /l, j, w/
	(3;00 - 3;5)	/g/ /s/	/ɹ/, /s/, /b/ /k/, /d/, /p/, /f/, /ʃ/	/p/, /l/ /t/, /dʒ/ /g/, /f/	/dʒ/	/b, d/ /s/, /ɾ/ /f, χ, ħ, ʃ/ /dʒ/ /tˤ, dˤ/ /l/	/χ, ħ/ /ɾ/,

Table 7-1: Summary of segmental acquisition
Note: Blue highlights indicate fluctuation of the age of acquisition of phonemes

Age	2;6 - 2;11		3;0 - 3;5	
Language	E	A	E	A
1. Substitution error patterns				
Fronting	MF, SF, AM	MF, AM	MF, AM	MF, SF, AM
Backing	MF	MF, SF		MF
Stopping	MF, AM	AM	MF, AM	

De-affrication	AM	AM	AM	AM
De-emphasis		MF, SF, AM		MF, SF, AM
Lateralization of /r/	AM	SF, AM	AM	AM
/ɾ/ ->/ɹ/		MF, SF		MF, SF
/ɹ/->/ɾ/	AM		SF	
Glottalization		MF		MF, SF
2. Assimilation				
De-voicing	SF, AM	SF	SF, AM	SF
Voicing			AM	
Assimilation	AM	MF, AM	AM	MF
3. Syllable error patterns				
Final consonant deletion	SF			
Cluster reduction	SF, AM		AM	
Weak syllable deletion		MF, SF		MF

Table 7-2: Summary of error patterns cross-linguistically

7.1.1.1 Individual variations

Discrepancies in phonological acquisition among children are well documented in the fields of both monolingual and bilingual phonological acquisition. These differences in rate of acquisition are the result of several factors. Some of these factors are universal and may affect the acquisition profile for both monolingual and bilingual children, such as age, gender, socioeconomic status and number of siblings. Others are exclusive to the bilingual acquisition, such as the age of first language exposure and pattern of language exposure.

In this study, language exposure pattern is considered to play a crucial role in determining the course of phonological acquisition and development of bilingual children. Other factors such as age and socioeconomic status are controlled. The effect of gender on the participants' acquisition and development was not examined because of the sample size of this study.

In previous chapters, I discussed the controversy that surrounds the dominance construct at the theoretical and methodological levels. Its efficiency has been widely disputed. In order to avoid any misconceptions and unjustifiable implications

associated with that construct, I refrain from including it in this investigation. Instead, the notion of "language exposure" is used to address the effect of receiving more or less interactive input in a certain language on the phonological development of the bilingual participants.

1. PCC

Table 7-1 illustrates the PCC scores of the participants at the beginning and end of the data collection period cross-linguistically. There appears to be a direct correlation between PCC scores and language exposure patterns in each language. In English, MF had the highest score across the participants, with an accelerated acquisition compared to English monolinguals. MF communicated in English in both the nursery and at home. SF scored 10% less than MF, and English exposure was limited (to some extent) to the nursery in an English monolingual environment. Her score is within monolingual norms. AM's accuracy was the lowest among the participants. He was only exposed to an English monolingual environment at the nursery part-time, and he had a minor delay compared to English monolingual children. Longitudinally, an increase of all the children's PCC is observed. The gap between MF's and SF's scores has decreased; they scored 93% and 91.6% respectively. Their scores were higher than the PCC scores of their age-matched English monolingual children. AM's score was less by 10% but is considered to be within monolingual norms.

The participants' Arabic PCC scores show different patterns, in which SF and AM have a similar accuracy of 64% and 70.5% respectively. Their results demonstrated an accelerated acquisition in comparison to their age-matched Arabic-

speaking children. MF had the lowest score and a delay in accuracy in comparison to Arabic children. Longitudinally, an increase of the PCC scores across all the participants was observed. However, SF had the highest accuracy score, while MF had the lowest. Her PCC is still considered accelerated compared to Arabic-speaking children, while AM was within the normal range and MF continued to have a deceleration in her accuracy.

With a strong correlation between language exposure patterns and accuracy results, it is possible to infer that high exposure positively correlates with accuracy. However, this interpretation would not be precise. There appears to be a certain threshold for a requisite amount of language exposure, and when that level is met, the language is acquired and developed within monolingual norms. SF received less language exposure in Arabic than AM, yet she had a higher accuracy score than him. This finding is also supported by Gutiérrez–Clellen and Kreiter (2003). They explored the impact of different language exposure patterns on Spanish/English bilingual children living in the United States. The bilingual participants were divided into two groups in accordance with the language spoken at home: Spanish and English. All participants were school-aged children who were exposed to English at school. The findings indicated that children who were exposed to Spanish at home performed better in Spanish grammatical skills than children who were exposed to English, but children who were exposed to English did not perform better than the other group in English grammatical skills. Even with less English exposure, the bilinguals were able to acquire appropriate English grammatical skills, indicating that while a higher quantity of input may not result in an accelerated acquisition, a certain amount of exposure is required, and beyond it, no difference in attainment is observed.

2. Phonemic repertoire

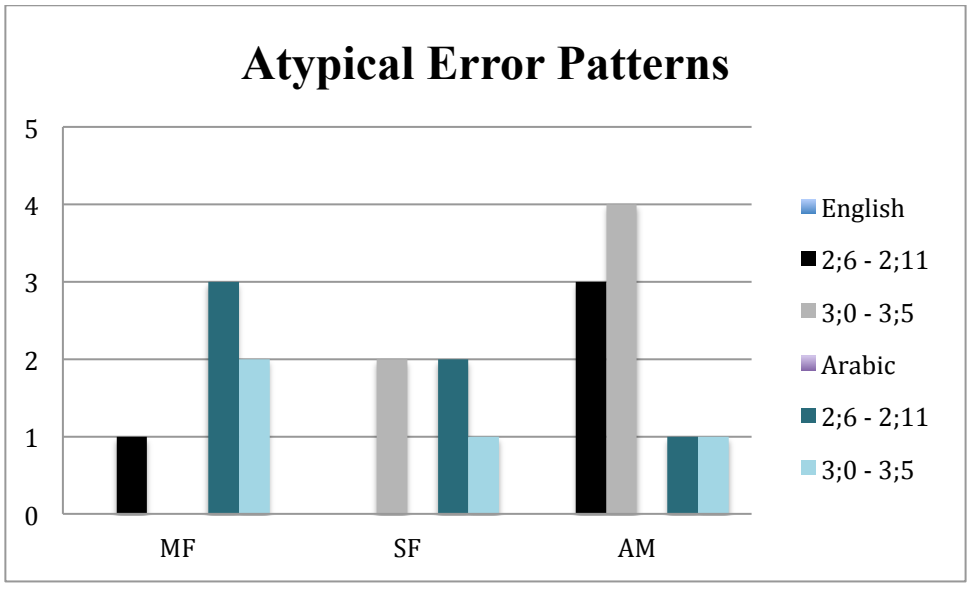
The analysis of the participants' phonemic inventories reveals trends similar to their PCC scores. Regarding the participants' English phonemic inventories, MF had the largest, while SF and AM had comparable size inventories. Before the age of three, MF mastered most of the plosives and fricatives as well as all the nasals, affricates, approximants and laterals. After three, her consonant inventory was completed, except for interdentals. SF, on the other hand, mastered one plosive and a fricative, affricates, all the nasals and approximants and the lateral. It is worthy to note that she mastered most of her plosives and some fricatives before the age of three, however, this mastery underwent some fluctuation during the duration of data collection (Table 7-1). Additional plosives, fricatives, and non-lateral approximant were added to her inventory after three. AM had a reasonable size of consonant inventory, with some plosives, fricatives, nasals and all approximants. After he turned three, his inventory expanded to include all the plosives, one extra fricative, lateral /l/ and one affricate. English-language specific phonemes such as /ŋ/ and /ɹ/ were mastered by MF and SF and not by AM. This difference could be attributed to his language exposure in English, in which he received substantially less language exposure in English than the participants.

For Arabic acquisition, AM had the largest consonant inventory among the participants, followed by MF. Before he turned three years old, AM had mastered all the plosives, nasals, approximants and laterals as well as some fricatives. After three, his inventory expanded to include two pharyngeal consonants. A fluctuation of the acquisition of the tap /ɾ/ between mastery and acquisition levels was also observed. MF had a good size inventory with all plosives, nasals and approximants as well as

some fricatives. Her inventory expanded after the age of three to include one affricate. No Arabic-specific consonant was included in her inventory during the whole period of data collection. Surprisingly, SF had the smallest consonant inventory before the age of three across the other participants. She mastered some plosives, one fricative and all nasals and approximants. However, after the age of three, her inventory expanded rapidly to include plosive, fricative, pharyngeal, affricate, lateral and emphatic consonants. The flap/tap /ɾ/ was mastered after 3;2 but its accuracy reverted to acquisition level in the last month of data collection. As observed for her PCC's score, there seemed to be a rapid acceleration after the age of three.

3. Error patterns

The discussion of the influence of language exposure on error patterns will be limited to the number of atypical errors only to determine any relationship between atypical development and language exposure patterns. Typical error patterns will be discussed in following sections.



Graph 7-1: Occurrences of atypical error types cross-linguistically

Graph 7-1 exhibits the number of atypical errors types across the three participants. The vertical axis presents the number of error types, while the horizontal axis displays the participant's longitudinal production of atypical error types cross-linguistically. Different profiles of acquisition among the participants appear to correspond to language exposure patterns. MF's production exhibits more atypical error types among the three participants in Arabic languages and the least in English. Backing error pattern was evident in her languages before she turned three. After three, this error was suppressed in English production but continued to persist in her Arabic production until she turned 3;4. A sharp decline was noticed for this error pattern at the last two months of data collection period. In addition, two atypical error patterns were observed in her Arabic production but not in English: /ɾ/ ->[ɹ] and assimilation. Over the duration of data collection, the realization of the tap/flap /ɾ/ into the approximate [ɹ] demonstrated an overall steady decline, while assimilation error did not exhibit the same trend.

AM's production, on the other hand, demonstrated higher atypical errors in English and the least in Arabic among the participants. In English, five atypical error patterns were observed in his production: lateralization of /r/, /ɹ/->/ɾ/, devoicing, voicing and, assimilation. The highest frequency of the lateralization error pattern was observed at the beginning of the data collection period; after the age of 2;6, a longitudinal steady decrease was observed. After the addition of Arabic /ɾ/ in the participant's inventory, lateralization error pattern appeared to be reduced, while the substitution of /ɹ/->[ɾ] was on the rise and reached its highest level at the last month of the data collection period. In addition, an assimilation error pattern type was observed in his production that constitute; voicing, devoicing and assimilation. Generally, voicing occurred in very low frequency, except for the age of 3;1 where it marked a

spike in the production of that error. After that age, a steady decrease was observed. Devoicing was observed to occur in higher frequency than voicing in the participant's production, especially before three years. After three, a noticeable decrease was observed. A similar pattern is observed for assimilation, where an observed decrease was seen after three. In Arabic, two atypical errors during the period of data collection were observed: assimilation and deaffrication. While assimilation was suppressed after the age of 2;7 years, deaffrication still occurred during the data collection but with low frequencies after three. Deaffrication is considered a typical error among Arabic-speaking children under the age of three.

SF's production did not exhibit clear patterns across her languages; she had two atypical errors in English after three but none before that age, while in Arabic her production of atypical error patterns decreased from two to only one after she turned three. Devoicing and /ɹ/->[ɾ] were two error patterns reported in her production and are considered atypical among English-speaking children. Devoicing was persistent during the period of data collection; however, this error is only typical for English-speaking children under the age of three. Thus, this persistence is considered atypical because it is resolved earlier by monolingual speakers. It is worthy to note that there was a sharp decline in the frequency after the age of 3;1 years, but the error continued to occur frequently even at the last month of the data collection period. The other atypical error appeared abruptly (from 3;2 through 3;4 years) and resolved at the last month of data collection. For her Arabic production, two error patterns were reported to be atypical for under three years old: backing and /ɾ/ ->[ɹ]. The backing error pattern is considered to be a typical error pattern for Arabic-speaking children over the age of three. For the participant, the noticeable frequency of this error was only observed during 2;6 years, after which a decline was reported with overall low

frequency. As for the substitution of /ɾ/ ->[ɹ], a steady increase was noted at the beginning of data collection until the participant reached 3;1 years. After that, a sharp decline was observed with rare occurrences.

These findings suggest that there are two distinct profiles for error patterns. The first one exhibits a cross-linguistic use of the same error patterns. Backing error pattern was used by MF across her languages, but it resolved earlier in the English where she had more exposure. AM was observed to deploy lateralization and assimilation in both languages, but assimilation error was persistent in English even after its drop in his production in Arabic. SF was observed to use devoicing across her languages. Its occurrences demonstrated an overall decrease cross-linguistically, but it occurred in higher frequency in English than in Arabic. This error pattern is considered a typical error among Arabic-speaking children and atypical in English-speaking children after the age of three. Thus, the higher frequency of occurrence in a language where it is atypical error could not be explained directly by exposure patterns. However, similar trends were noticed throughout her acquisition profile, where English attainment was demonstrated to be higher in some aspects while Arabic attainment was higher in other aspects of her phonological acquisition. The second trajectory appears to limit the use of an error pattern to one of the participants' languages. The use of /ɾ/ ->[ɹ] and assimilation error patterns by MF was limited to her production in Arabic. The three error patterns limited to English in AM's production were /ɹ/->/ɾ/, devoicing and voicing. SF was observed to use backing and /ɾ/ ->[ɹ] error patterns in Arabic only, while /ɹ/->/ɾ/ was also observed in her English production. Atypical error patterns observed in MF and AM production seem to correspond to language exposure patterns: more language exposure results in less atypical error in that language. However, this pattern is not applicable to SF's data,

which could be explained by her language exposure pattern of receiving not equal but relatively comparable exposure in both languages.

Various studies reported the occurrences of atypical error patterns in the production of their bilingual and multilingual participants (Holm & Dodd, 1999; Goldstein *et al.*, 2005; Yang & Zhu, 2010; Hambly *et al.*, 2013). The proportion of these errors and their frequency is used to support different positions towards bilingual acquisition: The first considers bilinguals as a different population than monolinguals, and the occurrences of atypical error patterns are expected within this population norms (Holm & Dodd, 1999); another suggests that bilinguals exhibit similar linguistic behaviours to monolingual children and that the proportions of atypical error in their production are very low (Goldstein *et al.*, 2005). The inconsistency in the literature may be attributed to conceptual and methodological differences. Holm and Dodd's findings are applicable to sequential bilingual acquisition, while Goldstein *et al.* included different bilingual populations and did not make that distinction. This tension has clinical implications in over referral or under referral of bilingual children to speech therapy. The findings of this study suggest that the high proportion of atypical error patterns is contingent to lack of sufficient language exposure. This lack of linguistic resources may motivate the use of this atypical error to fill in the gap. The bootstrapping hypothesis (Gawlitzek-Maiwald & Tracy, 1996) proposed that the acquisition of a linguistic structure in one language fulfils a booster function for the other language, which could constitute a "temporary pooling of resources in a weaker version" (p. 403). Longitudinally, the frequency of atypical errors showed noticeable decrease, suggesting that children can reach monolingual norms with more language exposure. Thus, the appearances of these

errors could serve a transitory facilitative function in the pooling of resources, as proposed in the hypothesis.

7.1.1.2 Sequential development

Longitudinal acquisition data allow for careful examination of the sequential development of the phonological systems of bilingual children. In this section, sequential development is discussed in detail against the acquisition of PCC, phonemic repertoire and error patterns.

1. PCC

Table 7-1 exhibits the participants' PCC scores at the beginning and end of data collection period. An increase of accuracy scores is observed longitudinally and cross-linguistically among all the participants with varying degrees.

2. Phonemic repertoire

Table 7-3 illustrates the sequential development of phonemes across the three participants. An overall expansion of the participants' inventories is observed cross-linguistically. The first stage, marked by number 1, indicates the mastered repertoire at the beginning of data collection period with 90% accuracy. Sequential numbers refer to the succession of phoneme mastery regardless of the age of acquisition, which varies cross-linguistically and across the three participants. Some observed tendencies are as follows:

1. Convergence and divergence in the acquisition of similar phonetic types across languages and participants

2. Reversals of the acquisition of some sounds from mastery to acquisition or customary levels across languages and participants

3. Mastery of higher complex sounds before less complex sounds

Seq.	English			Arabic		
	MF	SF	AM	MF	SF	AM
1	/m, n, ŋ/ /p, b/, /t, d/, /k/, /f/, /ʃ/ /tʃ/, /l/ /j, w/	/m, n, ŋ/ */b/, */k/ /tʃ, *dʒ/ */l/, /j, w/	/m, n/ /b/, */t/, */k/ /s/, */l/ /j, w/	/n/ /b/, /ʔ/ /t, d/, /k, g/ /f/, /w/	/m, n/ /ʔ/, /t/, /*k, *g/ /f/, /h/ /j, w/	/m, n/ */b/, /ʔ/ /t/, /k/ */z/, */ħ/, /l/, /j, w/
2	/dʒ/	/p/, /g/ */f/, */s/	/d/	*/ʃ/	*/b/, /f/, /s/ */dʒ/	/d/
3	*/g/	/v/	*/p/	*/j/, /m/	*/ʃ/	/s/
4	/ɹ/	/z/	/f/, */dʒ/	/dʒ/	/l/	/g/, /f/,*/ð/,
5	/s/	/ɹ/			*/ɾ/	*/ʕ/
6					/dˤ/, /θ/, /ħ/	*/ɾ/,
7					/tˤ/	/χ/

Table 7-3: Sequential development of consonants

Regarding the first tendency, there are some observed similarities and discrepancies in the acquisition of sounds cross-linguistically among the three participants. Convergence was observed in the early acquisition of sounds such as nasals, voiceless velars, approximants and lateral approximants and the late acquisition of the liquid /ɹ/, /ɾ/ cross-linguistically. A similar order of acquisition was

also reported in Yang and Zhu's (2010) case study of a triangle child acquiring Spanish/Taiwanese/Mandarin simultaneously. Other trends are observed as well, such as the acquisition of voiceless sounds before voiced (e.g. /s/ before /z/ and /k/ before /g/) and plosives before fricatives.

Variations among participants are also observed. For example, MF acquired most of her shared sounds at similar rates. Other participants showed more variation in the acquisition of similar phonetic types cross-linguistically. Different patterns of development of similar sound types have also been documented in the bilingual literature (Holm, 1998; Yang and Zhu, 2010). Holm (1998) reported that Cantonese/ English bilinguals acquire shared phonemes at different rates.

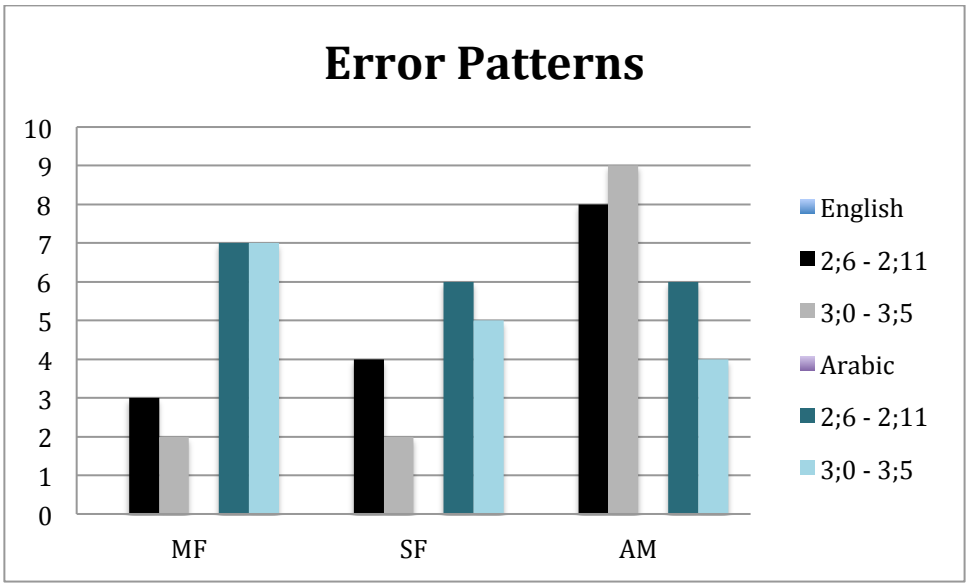
The second tendency indicates the occurrences of fluctuation of the age of acquisition across the participants and languages. This trend is also reported in the literature in both bilingual and monolingual acquisition and across languages (Prather et al., 1991; Smit et al., 1990; Schnitzer & Krasinski, 1994; Alqattan, 2015; Mayr & Lewis, 2015). While it is difficult to provide a coherent explanation for regression in the phonemic acquisition, scholars have provided several interpretations. Some attribute this reversal to individual differences in cross-sectional type studies across the participants in each age group (Smit et al., 1990); however, it is also reported in longitudinal case studies (Schnitzer & Krasinski, 1994) as well as in the current study for all the participants. Another explanation was provided by Moskowitz (1970). He claimed that these seemingly fluctuations are not a regression in acquisition but signify "Phonological Idioms," or sounds that have been produced correctly by children in ascribed lexical items that have been memorized but were not acquired as separate phonological units (p. 212). A third possibility is seen as an effect of the

reorganization of phonological space as a result of an expansion in the segmental repertoire of the child (Ingram, 1989, cited in Mayr & Lewis, 2015).

The third observed tendency, with low frequency, concerns the sequence of acquisition that does not always reflect ease of articulation. More complex sounds, such as the affricate /tʃ/, were mastered before fricatives by SF. Affricates are characterized by the oro-motor complexity and are reported to be acquired after fricatives by English-speaking children (Zhu & Dodd, 2000; Mcintosh & Dodd, 2008). Another example of this tendency is the mastery of voiceless uvular fricative /χ/ before the voiceless post-alveolar /ʃ/ by AM in Arabic.

3. Error patterns

Graph 7-2 illustrates longitudinally the number of error patterns across languages produced by the participants. The vertical axis reveals the number of error types, while the horizontal axis displays the participant's longitudinal production of both typical and atypical error types cross-linguistically. For English production, MF and SF's error were developmental demonstrating a steady decrease, while AM's production displayed a slight increase, with additional error types after the age of three. For Arabic production, seven error types were persistent in MF's production before and after the age of three. On the other hand, SF and AM production of errors demonstrated an observable decrease in the number of error types.



Graph 7-2: Occurrences of error patterns types cross-linguistically

7.1.2 Cross-linguistic interaction

Table 7-1 and 7-2 illustrate a summary of the findings of the current study across three variables: PCC, phonemic repertoire and development of error patterns. Paradis and Geneses's (1996) model was used to account for cross-linguistic interaction in the phonological development of the participants.

7.1.2.1 Transfer

The transfer is observed mainly in the acquisition of the following phonemes: /ɾ/, /ɹ/, /l/ and /ŋ/. For the acquisition of the phoneme /r/, MF and AM exhibited drastically different attainment levels cross-linguistically, while SF's acquisition developed at a comparable pace across her languages. In MF's case, the phonological transfer was unidirectional. Arabic tap/flap /ɾ/ was frequently realized as the approximant [ɹ]. Since the approximant /ɹ/ is the standard realization of that sound in

the participant's variety of English, it is reasonable to assume that the direction of transfer was from English to Arabic.

Examples

/məri:dˤ/ -> [məɹi:d]: sick

/χejaɾ/ -> [hejaɹ]: cucumber

/ɾəħman/ -> [ɹəhmɑ:n]: the merciful

Longitudinally, MF began to differentiate the two sounds and was able to produce the target Arabic /ɾ/ for 30% of total production at the last month of data collection.

On the other hand, both SF and AM exhibited varying degrees of bidirectional transfer, along with lateralization error patterns for the production of the phoneme /r/. Nonetheless, SF deployed the lateralization process more in her production of English than in Arabic, which was resolved after she turned 2;9 years. The phoneme /ɹ/ was realized as the Arabic [ɾ] for 7% of its total production. It stabilized at the last month of data collection without any traces of interaction. As for the production of Arabic phoneme /ɾ/, 26% of its total production was substituted with the English approximant [ɹ]. After the participant reached 3;2 years, her production of Arabic /ɾ/ improved and the percentage of interaction decreased. This change demonstrated an increased level of language differentiation. In addition, the interaction level in the production of Arabic /ɾ/ seemed to be noticeably higher than in English. Moreover, the data showed some interesting trends during the period when the participant was 3;2 through 3;4; during this time, her production accuracy of Arabic /ɾ/ reached 100%, while the production of her English /ɹ/ was affected and was realized as tap/flap [ɾ] on several

occurrences. However, at the last month of data collection, the participant's production accuracy of Arabic /ɾ/ decreased to 85% and was occasionally substituted by the English [ɹ].

Examples

a. Arabic

/ sejaɾah/ -> [sejaɹah]: car

/ʃəʕaɾ/ -> [ʃəʔaɹ]: hair

b. English

[kærət]: carrot

[pʌtərflaɪ]: butterfly

AM's acquisition pattern of the phoneme /r/ exhibited both convergence and divergence from MF's and SF's acquisition. The similarity to MF was manifested through his different attainment level of this phoneme cross-linguistically, which could be attributed to receiving more language exposure in Arabic. On the other hand, the transfer was not totally uni-directional, displaying similar trends to SF's acquisition pattern but with high correlation between language exposure patterns and directionality of transfer. In terms of the acquisition of the approximant alveolar /ɹ/, 44% of its total production was realized as alveolar tap /ɾ/. At the end of data collection, /ɹ/ was realized as /ɾ/ for 68% of its production, showing no sign of stabilization. Moreover, 60% of its production was not produced as its target; however, it was lateralized as [l] for 30% of its total production. The intensity of this error pattern decreased over the period of his acquisition. The target production of /ɾ/

was realized as the English approximant alveolar [ɹ] for 5% of its total production. The same error pattern found in English for the production of this sound segment also appeared in Arabic production. Lateralization was evident, occurring for 23% of its total production. Nonetheless, a reduction was observed longitudinally and was reported in 20% of production at the last month of data collection, compared to its realization in 40% at the first month of data collection.

The phonological transfer was also exhibited in the production of the Arabic phoneme /l/ and was substituted by the English dark /ɬ/ infrequently by two of the participants: MF and SF. On the other hand, the English phoneme /l/, including its prevocalic non-velarized /l/ and the postvocalic velarized /ɬ/ varieties, was acquired and stabilized early during the data collection period by both participants. As for Arabic /l/, a marginal percentage of its production did not reach its target and was infrequently realized as dark [ɬ] (less than 10% by MF; 1.5% by SF). It was only stabilized at 3;1 years by MF. Two types of errors could be identified: cross-linguistic transfer and assimilation. These errors may reflect omitted or replaced pharyngealized segments. The transfer of this allophonic rule appeared to be in one direction. Interestingly, dark /ɬ/ was reported to be acquired after six years (Smit *et al.*, 1990) by English monolingual speakers. The participant acquired this segment earlier and also extended the allophonic rule to their Arabic production.

Examples:

a. Reflect an English allophonic rule:

/ɾədʒal/ -> [ɹədʒaɬ]: man

/ðejl/ -> [ðejɬ]: tail

b. Adjacent to a pharyngeal consonant:

/ boɾtuqali/ -> [bəttɛgalˤi]: orange color

/ zəʕlaniːn/ -> [zəlˤɑniːn]: upset (plural)

In addition, the production of the English nasal velar /ŋ/ was subject to uni-directional transfer and delay by AM only. It was realized for 45% of its total production as either [ng] or [nk]. This error pattern was not found in the production of the other two participants, reflecting an interaction between the two phonological systems rather than a developmental trend. The reason is that the participant received a noticeably higher level of language exposure in Arabic, and this phoneme is not part of the Arabic phonemic inventory. Moreover, his acquisition did not show any signs of stabilization at the end of the data collection period. English monolingual children were able to master that sound between 2-3 years old, as reported by McIntosh and Dodd (2008). Thus, his acquisition of that phoneme indicates a delay.

7.1.2.2 Acceleration and delay

Table 7-1 illustrates the participants' results in comparison to English and Arabic monolingual studies (Dodd *et al.*, 2006; McIntosh & Dodd, 2008; Alqattan, 2015). The remaining two variables, namely acceleration and delay, are relational variables and cannot be judged independently, as discussed previously. The following trends were observed:

1. Acceleration of: (1) shared sounds at an early stage (MF); (2) and language-specific sounds in Arabic (SF, AM)

2. Delay in the language where insufficient language exposure is received (Arabic: MF; English: AM)

Acceleration of shared sounds was observed in the phonemic inventory of MF cross-linguistically before the age of three. This acceleration could be attributed to interaction, as acceleration was observed in her production of shared sounds cross-linguistically. On the other hand, acceleration was also observed in the size of SF's and AM's phonemic inventories in Arabic for Arabic-specific phonemes in comparison to age-matched Arabic-speaking children.

Delay, as manifested by PCC scores and the frequency of error patterns, correlated directly with language exposure patterns. MF's PCC score in Arabic revealed a case of delay in comparison to Arabic monolinguals as well as the frequency of error patterns in Arabic.

The findings of this study demonstrated the impact of environmental factors, language exposure pattern in particular, in shaping the acquisition course of simultaneous bilingual children. Other environmental and linguistic factors were considered in the analysis, but no direct relationship between these aspects and phonological attainment or interaction was observed. A discussion of the potential influence of parental accent and cross-linguistic structural differences will be presented in the following paragraphs.

The effect of the accent of the children's parents on their production of error patterns was assessed. The significance of considering this factor is to confirm that these errors are the result of cross-linguistic interaction and not influenced by the

parents' production of these segments. This concern is relevant in cases where the parents are not native speakers of the other language that their children are acquiring. In the current study, all the parents of the participants were native speakers of Arabic who were considered second language learners of English. The findings reveal that there is no evidence to support the effect of parental foreign accent on their children's acquisition of English. For example, English /ɹ/ was realized as Arabic tap/flap /ɾ/ by MF's mother and to some extent her older sibling. However, it did not influence her acquisition of English /ɹ/, even though they communicate with her in English on a daily basis. It also had no effect on her acquisition of the Arabic tap/flap /ɾ/, as she did not reach even a customary level at the end of data collection period. As for AM and instances of transfer from Arabic to English, the role of parental input was considered. However, it was concluded that it had no effect as his parents communicate with him in Arabic and his older sibling's production did not exhibit this error pattern. Comparably, SF's mother's accent did not show any correlation with the participant's production. As for Arabic, the influence of the parents' dialect on their children's acquisition was reported in Khattab's (2002, 2006) studies. She concluded that some aspects of children's segmental acquisition could be traced to their parents' accent in Arabic, and if this were not accounted for, a different conclusion might be reached in which this variation in the bilingual production would be attributed to possible interaction effect and not to accentual aspect in their parents' production. Since the parents of all participants in this study spoke the same dialect, this factor was controlled, and any differences in the Arabic production across the three participants were attributed to different language exposure patterns not dialectal, as discussed earlier.

Another potentially influential factor concerns linguistic aspects of the particular language combination of the bilingual children. Cross-linguistic structural differences between particular language combinations are hypothesized to have a crucial impact on interaction. It is assumed that different language combinations interact in different ways. Two views are circulated in that regard: one acknowledges the influence of cross-linguistic structural differences but assumes that it had limited influence on interaction, and the other view hypothesizes that the extent and directionality of cross-linguistic interaction is directed merely by the complexity of the structure in question (Döpke, 1998; Hulk & Müller, 2000). The proponents of the first view often stress that directionality of interaction is influenced by dominance. This view is widely acceptable in the domain of phonology (Lanza, 2000; Paradis, 2001; Gordeeva, 2006) and supported in the findings of the current study. The other view is conventional in other linguistic domains, such as syntax. In that view, the direction of transfer for example would be determined by the complexity of ambiguous structures in this particular language combination. Gordeeva (2006) argued that there is a fundamental difference between morphosyntactic structures and sound structures in which the physical manifestation of the later is dual. It combines two levels: mental and physiological, while "this dichotomy is absent in the production of morphosyntactic structures" (p. 257). These differences between phonology and other linguistic domains may explain some of the variability in the data in the bilingual acquisition field. The findings of this study support the less extreme view, in which in-between language ambiguity is found to determine the areas of interaction but did not direct the directionality or frequency of interaction. For example, /r/ in both Arabic and English is a late acquiring sound; its complexity differs in both languages. Arabic learners usually acquire this phoneme between four

and six, while English-speaking children normally acquire it over six. The directionality of transfer was found to be directed from English to Arabic in the case of MF and SF and from Arabic to English in AM's case, where he had more language exposure to Arabic regardless of the phoneme complexity.

7.2 Implications

I have pointed out earlier that thousands of Saudi and Gulf nationals had been offered scholarships in English speaking countries. A large number were sent for higher education degrees with their families. Several scholarship holders had their young children with them or gave birth while they perused their degrees. Thus, the number of Arabic/English bilingual children rose recently and highlighted the scarcity of this language combination in the literature, especially in the field of child phonological acquisition and development. Implications of the research findings will be discussed.

7.2.1 Theoretical implications

This study attempted to shed some light on relevant issues in bilingual acquisition research with reference to phonological acquisition data. Holm (1998) discussed the potential contribution of the bilingual phonological development research in addressing pertinent questions in bilingual research (concerning differentiation, the role of input, successive versus simultaneous acquisition, cross-linguistic interaction, the effect of specific language combinations) that have

implications to the theories of bilingualism. The implications of the findings of this study will be discussed in relation to language exposure patterns and cross-linguistic interaction.

It has been proposed that bilingual children demonstrate lesser accuracy rates in some manner classes than monolingual children (Fabiano-Smith & Goldstein, 2010). Scholars attributed these differences in attainment between monolinguals and bilinguals to different factors. One of these factors is the difference in the amount of input received across bilinguals and monolinguals. Though the findings of this study support the effect of language exposure patterns on the phonological acquisition profiles of the bilingual children cross-linguistically, they also suggest that bilingual children can accelerate or reach monolingual norms with quantitatively less language exposure than monolingual children.

The findings of this study support that cross-linguistic interaction is a support mechanism deployed differently by bilingual children thus supporting the bootstrapping hypothesis proposed by Gawlitzek-Maiwald and Tracy (1996). It remains whether this interaction continues after these children have fully developed their phonological systems and under what conditions will it be manifested. In terms of models accounting for interaction, the findings indicate that delay is not a result of interaction but correlated to language exposure patterns. Another matter of great importance is addressing the acceleration of language-specific phonological structure that has received little attention in the literature and was not accounted for in the existing models of interaction. Acceleration of language-specific features was observed in this study, however, whether this acceleration is related to interaction or caused by other factors remains undetermined and should be the subject of future investigations.

7.2.2 Clinical implications

Several scholars had discussed the scarcity of appropriate assessment measure that could result in either over-identification or under-identification of language impairment for this population (Bedore & Peña, 2008; Fabiano-Smith *et. al*., 2015). The result of this study suggests that bilingual children were not only able to meet monolingual norms but also demonstrate acceleration for selected phonological skills. Overall, number and frequency of atypical error type(s) were due to cross-linguistic interaction and language exposure patterns. Bilinguals who receive amble language exposure in both languages are expected to have acquisition levels that commensurate to their age-matched monolingual peers cross-linguistically. Therefore, an assessment tool should consider that bilingual children are able to reach monolingual norms once they are giving the opportunity to do so in both languages. Any delay in the acquisition is a result of environmental factor such as language exposure patterns that need to be addressed in any assessment.

7.2.3 Practical implications

An important finding of this study is the role of language exposure patterns on phonological attainment and interaction. Language proficiency is susceptible to different elements, including children's variability, maturation, language combination, and exposure. These elements could affect bilingual development at different stages and by different degrees. Many bilingual children's parents have expressed concern regarding the speech development of their children, especially the manifestation of

language transfer and the accents of their children's speech production. Other parents may refrain from using their native language for fear that the exposure of two languages could negatively affect their children's linguistic development and cause it to be delayed. Interaction should be viewed as normal part of bilingual phonological and linguistic development and thus be viewed positively. Parents are encouraged to provide their children with ample exposure opportunities of their languages.

After these bilinguals return to their home countries, they will be faced with different challenges like cultural differences and a monolingual school system in some cases. Some of them may have atypical pronunciation of Arabic sounds, which could create a state of tension for these bilinguals. Lack of understanding of what stages bilinguals go through in their linguistic development may have hindering effects in terms of assimilation and may cause anxiety. Bilingual children's accents are not a defected version of monolingual phonology but rather an inevitable part of their linguistic and phonological development and should be viewed favorably. For bilinguals, it seems that their ability to differentiate phonological systems increases over time, with sufficient language exposure. Another useful finding of this study is that it provides a descriptive account of potential problematic language structures for Arabic learners of English as a second language. Teachers could address these difficulties by designing more focused activities for learners to help them overcome these problems.

7.3 Limitations

Limitations related to research design are recognized. The first limitation concerns the lack of an attested monolingual baseline. Different studies have

addressed that gap in the literature and included monolinguals in both languages (Kattab, 2006), which is helpful for its potential to minimize the effect of methodological variability on the outcome of the studies. However, most of these studies were able to include monolingual groups because they were cross-sectional. There were multiple reasons for not including monolingual subjects in this study. First, the longitudinal design was very demanding. Locating parents who were committed to recording their children on a monthly basis was difficult. Moreover, the time frame of this study made it difficult to include more participants, as the data analysis process was both time-consuming and laborious. Finally, even if I could have managed the obstacles addressed earlier, the acquisition patterns of three monolingual children in each language could hardly establish the norms of monolingual acquisition and development patterns, as developmental norms are widely susceptible to individual variations. Therefore, normative studies with rigorous acquisition criteria were selected, and monolingual norms were driven from them. Another challenge concerns the length of this research.

This study accounted for the speech production acquisition and development of three English/Arabic bilingual children for one year. The ideal age to address the research question was at two years old when children had acquired a substantial lexicon. Fortunately, three bilingual children within the same age group took part in this study. The concern was that some marked or language-specific phonemes, such as emphatic, were usually late acquiring sounds. It would be interesting to extend the data collection period of bilingual acquisition from the earliest stage of acquisition until their phonological systems are fully developed. A study designed to cover that gap would be extremely valuable.

Another limitation is related to the analytical framework deployed in this study that concerns segmental phonology and phonetic transcription. Super segmental features such as intonation or tonal could have added another dimension of analysis and addressed the phenomena of interaction more comprehensively. Thus the findings are limited to the scope of this approach. Another concern is the use of the perceptual method of analysis such as phonetic transcription. This method has been often criticised for its subjectivity (Ball *et al.,* 2013). Future research could benefit from using instrumental analysis to corroborate the findings of this study

An additional limitation is associated with the qualitative approach used for collecting data. The main aim was to account for the phonological acquisition of bilingual children for providing an understanding of the phenomena of interaction. Thus, the finding should be approached with caution and be further tested using a cross-sectional design due to the small number of the participants involved, which affects the generalizability of the findings.

7.4 Conclusion

The controversy over the extent of cross-linguistic interaction and its impact on phonological acquisition of bilingual children has motivated this investigation. A longitudinal case study design, typical of earlier investigations of phonological acquisition research, was used to address current issues in language combination that have been rarely studied for simultaneous first language phonological acquisition. This research design was appropriate in capturing the extent of interaction and assessing the effect of any environmental and linguistic confounding factors, which permits for the exploration of patterns and association. For data analysis, a segmental

approach was used for its rigorousness and capacity to quantify qualitative data. The findings indicated that cross-linguistic interaction occurred at very low frequencies at varying degrees across the participants. This interaction was manifested in terms of transfer and acceleration. Delay, on the other hand, was observed in phonological acquisition to be caused by an insufficiency in the amount of language exposure, which challenges some circulated conventions in the literature that view delay as an anticipated outcome of cross-linguistic interaction. The effect of language exposure on bilingual phonological acquisition was found to have multifaceted dimensions. For interaction, language exposure patterns were found to greatly influence frequency and directionality. Thus, the quantity of exposure was relative in that context. As for phonological acquisition and development, the quality of exposure was more significant. As a by-product of my research, my secondary finding unveiled that a certain threshold for language exposure in a language is needed in bilingual settings to reach monolingual norms. Beyond this threshold, extra attainment or accuracy may not have occurred. Participants received quantitatively less language exposure than monolinguals but were observed to accelerate in their phonological development. Therefore, future studies should measure the qualitative nature of this exposure and the degree of communication demands that it imposes on each of the linguistic environments of the bilingual children.

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Appendix 1

Language History Questionnaire

Name: MF

Please answer the following questions to the best of your knowledge.

PART A

1. When/at what age have you admitted your child to the nursery: eleven months
2. How often does your child attend the nursery:
a. Full time b. Part time
if part time, how many days_____and how many hours_____

_____
_____

3. Please rate the language proficiency of your child for both of her languages:
very poor poor fair functional good very good native-like
1_____ 2____ 3___ 4_____ 5___ 6_____ 7_____

Language	Speaking	Listening
1. English	7	7
2. Arabic	4	5

4. Does your child seem to have a foreign Accent in the language he/she speaks? If so, please rate the strength of your accent on a scale from 1 (not much of an accent) to 7 (very strong accent).

Language	Accent (circle one)	Strength
1. English	N	1
2. Arabic	Y	4

PART B

5. What language does your child usually speak to you at home? Please give an estimate in percentage if applicable.
1. Arabic: 30% 2.English: 70%

6. What language does your child usually speak to his/her father at home? Please give an estimate in percentage if applicable.
1. Arabic: 30% 2.English: 70%

7. What language does your child usually speak to his/her sibling(s) at home? Please give an estimate in percentage if applicable.

1. Arabic: 10% 2.English: 90%

8. What language do you usually speak to your spouse at home?
1. Arabic: 90% 2.English: 10%

9. Estimate, in terms of percentages, how often does your child use his/her languages per day (in all daily activities combined):

1. Arabic: 20% 2.English: 80%

10. Estimate, in terms of hours per day, how often does your child watch TV in both languages:
1. Arabic: 30% 2.English: 70%

11. Estimate, in terms of hours per day, how often does your child use his/her languages per day at home:
1. Arabic: 30% 2.English: 70%

12. In which languages does your child usually express his/her anger or affection:
1. Arabic: 10% 2.English: 90%

13. In normal does your child mix his/her both languages, on a scale from 1 (mixing is very rare) to 5 (mixing is very frequent). Write down the number in the box.

Relationship	Dominant language	Frequency of mixing
Mother	English	2
Father	English	2
Sibling(s)	English	1
Family members	English	3

14. In which language does your child usually do better?

Speaking: 1. Arabic 2.English

Understanding: 1. Arabic 2.English

Name: SF

Please answer the following questions to the best of your knowledge.

PART A
1. age when attending the nursery: 1 years 5 months 16 days
Data collection: 2 years and 5 months
2. When/at what age have you admitted your child to the nursery: 40 days
3. How often does your child attend the nursery: daily
a. Full time b. Part time
if part time, how many days_____and how many hours_____

_____
_____

3. Please rate the language proficiency of your child for both of her languages:

very poor	poor	fair	functional	good	very good	native-like
1_____	2____	3___	4_____	5___	6_____	7_____

Language	Speaking	Listening
1. English	5	7
2. Arabic	5	7

4. Does your child seem to have a foreign Accent in the language he/she speaks? If so, please rate the strength of your accent on a scale from 1 (not much of an accent) to 7 (very strong accent).

Language	Accent (circle one)	Strength
1. English	Y N	2
2. Arabic	Y N	2

PART B

5. What language does your child usually speak to you at home? Please give an estimate in percentage if applicable.
1. Arabic 90% 2.English 10%

6. What language does your child usually speak to his/her father at home? Please give an estimate in percentage if applicable.
1. Arabic 90% 2.English 10%

7. What language does your child usually speak to his/her sibling(s) at home? Please give an estimate in percentage if applicable.
1. Arabic 90% 2.English 10%

8. What language do you usually speak to your spouse at home?
1. Arabic 100% 2.English 0%

9. Estimate, in terms of percentages, how often does your child use his/her languages per day (in all daily activities combined):

1. Arabic 10% 2.English 90%

10. Estimate, in terms of hours per day, how often does your child watch TV in both languages:
1. Arabic50 % (NO TV only one h of songs) 2.English 50%

11. Estimate, in terms of hours per day, how often does your child use his/her languages per day at home:
1. Arabic 100% 2.English 0%

12. In which languages does your child usually express his/her anger or affection:
1. Arabic 50% 2.English 50 %

13. In normal does your child mix his/her both languages, on a scale from 1 (mixing is very rare) to 5 (mixing is very frequent). Write down the number in the box.

Relationship	Dominant language	Frequency of mixing
Mother	Arabic	2
Father	Arabic	2
Sibling(s)	Arabic	2
Family members	Arabic	2

14. In which language does your child usually do better?

Speaking: 1. Arabic 2.English

Understanding: 1. Arabic 2.English (Both)

15. If there is anything else that you feel is interesting or important about your language background or language use, please comment below.
She is very fast to learn both and to speak both. I noticed that she speak to the nursery in English and speak with family in Arabic she became an expert of picking which language of which.

Name: AM

Age: 2 years and 4 months

Please answer the following questions to the best of your knowledge.

PART A
1. When have you first arrived to the UK_____ born in the UK
2. When/at what age have you admitted your child to the nursery 25 months
3. How often does your child attend the nursery:
a. Full time b. Part time
if part time, how many days 2 and how many hours: 20 hours

_____
_____

3. Please rate the language proficiency of your child for both of her languages:
very poor poor fair functional good very good native-like
1_____ 2____ 3___ 4_____ 5___ 6_____ 7_____

Language	Speaking	Listening
1. English	4	5
2. Arabic	7	7

4. Does your child seem to have a foreign Accent in the language he/she speaks? If so, please rate the strength of your accent on a scale from 1 (not much of an accent) to 7 (very strong accent).

Language	Accent (circle one)	Strength
1. English	Y	4
2. Arabic	N	1

PART B

5. What language does your child usually speak to you at home? Please give an estimate in percentage if applicable.
1. Arabic: 90% 2.English: 10%

6. What language does your child usually speak to his/her father at home? Please give an estimate in percentage if applicable.
1. Arabic: 90% 2.English: 10%

7. What language does your child usually speak to his/her sibling(s) at home? Please give an estimate in percentage if applicable.
1. Arabic: 80% 2.English: 20%

8. What language do you usually speak to your spouse at home?
1. Arabic: 100% 2.English: 0%

9. Estimate, in terms of percentages, how often does your child use his/her languages per day (in all daily activities combined):

1. Arabic: 85% 2.English: 15%

10. Estimate, in terms of hours per day, how often does your child watch TV in both languages:
1. Arabic: 10% 2.English: 90%

11. Estimate, in terms of hours per day, how often does your child use his/her languages per day at home:
1. Arabic: 90% 2.English: 10%

12. In which languages does your child usually express his/her anger or affection:
1. Arabic: 90% 2.English: 10%

13. In normal does your child mix his/her both languages, on a scale from 1 (mixing is very rare) to 5 (mixing is very frequent). Write down the number in the box.

Relationship	Dominant language	Frequency of mixing
Mother	Arabic	1
Father	Arabic	1
Sibling(s)	Arabic	4
Family members	Arabic	1

14. In which language does your child usually do better?

Speaking: 1. Arabic 2.English

Understanding: 1. Arabic 2.English

Appendix 2

Error pattern	Reference	Description
1. Substitution error patterns		
Fronting	Dodd *et al.* (2003)	Place of articulation is moved to a more anterior position
Backing	ibid	Place of articulation is moved to a more posterior position
Stopping	ibid	Replacement of fricatives with stops
Gliding	ibid	Replacement of liquids /l, r/ with glides [w, j]
De-affrication	ibid	Modification of the affrication feature
De-emphasis	ibid	When emphatic sounds /tˤ, dˤ, sˤ, ðˤ/ are realized as their non emphatic counterparts [t, d, s, ð].
Lateralization of /r/	Vihman & Greenlee (1987)	Flap /ɾ/ is replaced by lateral [l]
/ɾ/ ->[ɹ]		The substation of the tap/flap alveolar /ɾ/ by the approximant alveolar [ɹ]
/ɹ/->[ɾ]		The substation of the approximant alveolar /ɹ/ by the tap/flap alveolar [ɾ]
Glottalization/ Glottal Replacement	Owaida (2015)	Replacing non-glottal sounds with glottal consonants
2. Assimilation		
De-voicing		When a voiced sound is realized as its voiceless counterpart /d/-> [t]
Voicing		When a voiceless sound is realized as its voiced counterpart /t/-> [d]
Assimilation	Dodd *et al.* (2003)	Influence of another phoneme in the target word
3. Syllable error patterns		
Final consonant deletion	ibid	Deletion of word final consonants (most commonly plosives, l, s and z)
Cluster reduction	ibid	Deletion of one consonant from the cluster
Weak syllable deletion	ibid	Deletion of an unstressed syllable